Arnold Schwarzenegger
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COMMERCE ENERGY BIOGAS/PV MINI-GRID RENEWABLE RESOURCES PROGRAM PROJECT 1.1 PROGRAM PLANNING AND ANALYSIS

PIER FINAL PROJECT REPORT

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Preface

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER program, managed by the California Energy Commission (Energy Commission), annually awards up to $62 million to conduct the most promising public interest energy research by partnering with Research, Development, and Demonstration (RD&D) organizations, including individual, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following six RD&D program areas:

- Buildings End-Use Energy Efficiency
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy
- Environmentally-Preferred Advanced Generation
- Energy-Related Environmental Research
- Strategic Energy Research

What follows is the final report for the PIER Commerce Energy Biogas/PV Mini-Grid Renewable Resources RD&D Program, Contract Number 500-00-036 conducted by the Commerce Energy Team, comprised of Commerce Energy, Itron, Inc. (formerly RER, Inc.), CH_2MHill, Behnke, Erdman and Whitaker (BEW), (formerly Endecon Engineering), Renewable Energy Development Institute (REDI) and Zaininger Engineering, Inc (ZECO). The report is entitled "*Project 1.1 Program Planning and Analysis Final Report*". This project contributes to the PIER Renewable Energy Program.

For more information on the PIER Program, please visit the Energy Commission's website at: http://www.energy.ca.gov/research/index.html or contract the Energy Commission's Publications Unit at 916-654-5200. Or you may review the PIER Commerce website at: http://www.pierminigrid.org, which was created for this contract, and summarizes each project of the contract.

Abstract

Project 1.1 Planning and Analysis

Project Purpose

This project was to support research on strategies for making renewable energy more affordable in California.

Project Objectives

- Define the initial program study area,
- Inventory the study area's potential photovoltaic and biogas resources to assess the potential and to help identify and prioritize potential demonstration projects,
- Identify a mini-grid, on which the potential distribution impact of the development of such resources can be assessed,
- Conduct power flow studies to identify and quantify the benefits of various levels of renewable energy penetration on the local electric distribution system,
- Identify net savings and benefits accrued by developing complementary resources.

Project Outcomes

This project developed an approach for tailoring resource development within a mini-grid to help meet the local needs for electric generation, Transmission and Distribution (T&D) reliability and environmental preservation, consisting of the following five elements:

- Identification of candidate study area
- Inventory of renewable resources
- Assess market potential
- Assess T&D grid impacts of fully realized mini-grid
- Prioritization of renewable DG projects within mini-grid

Project Conclusions

It is expected that the mini-grid concept will become more viable as markets evolve, and can be replicated in other locations in California. Additionally, financial market barriers can be addressed through continued public funding and legislative action.

Further research, such as that being performed under the Commerce Energy Program, can improve cost effectiveness of renewable distributed generation however there is a need for further research on impacts to the local T&D system to ensure system reliability.

Executive Summary

In June 2001, the Commerce Energy Team was awarded a programmatic contract under the California Energy Commission's Public Interest Energy Research (PIER) Program to conduct research on strategies for making renewable energy more affordable in California. The Commerce Energy approach involves assessing the combined potential of biogas and photovoltaic (PV) resources in a defined study area and identifying how these resources could be developed in a complementary and cost-effective manner.

The primary objectives for the Commerce Energy PIER Project 1.1, Program Planning and Analysis effort, are to:

- Define the initial program study area,
- Inventory the study area's potential photovoltaic and biogas resources to assess the potential of such resources and to help identify potential demonstration projects,
- Identify a mini-grid, on which the potential distribution impact of the development of such resources can be assessed,
- Conduct power flow studies to identify and quantify the benefits of various levels of renewable energy penetration on the local electric distribution system,
- Identify and prioritize individual demonstration projects, and
- Identify net cost savings and benefits that would accrue by developing complementary resources.

A multidisciplinary team led, by Itron and supported by CH_2M Hill, Renewable Energy Development Institute (REDI) and Zaininger Engineering Company (ZECO), is responsible for meeting these program-planning objectives. CH_2M Hill is responsible for undertaking the various biogas resource inventory assessments. Electric system characterization and data development, power flow and other studies related to the mini-grid are being undertaken by ZECO. The Commerce Energy Team conducted this research in a real world setting so that the findings could be applied elsewhere in California and thereby benefits more California ratepayers.

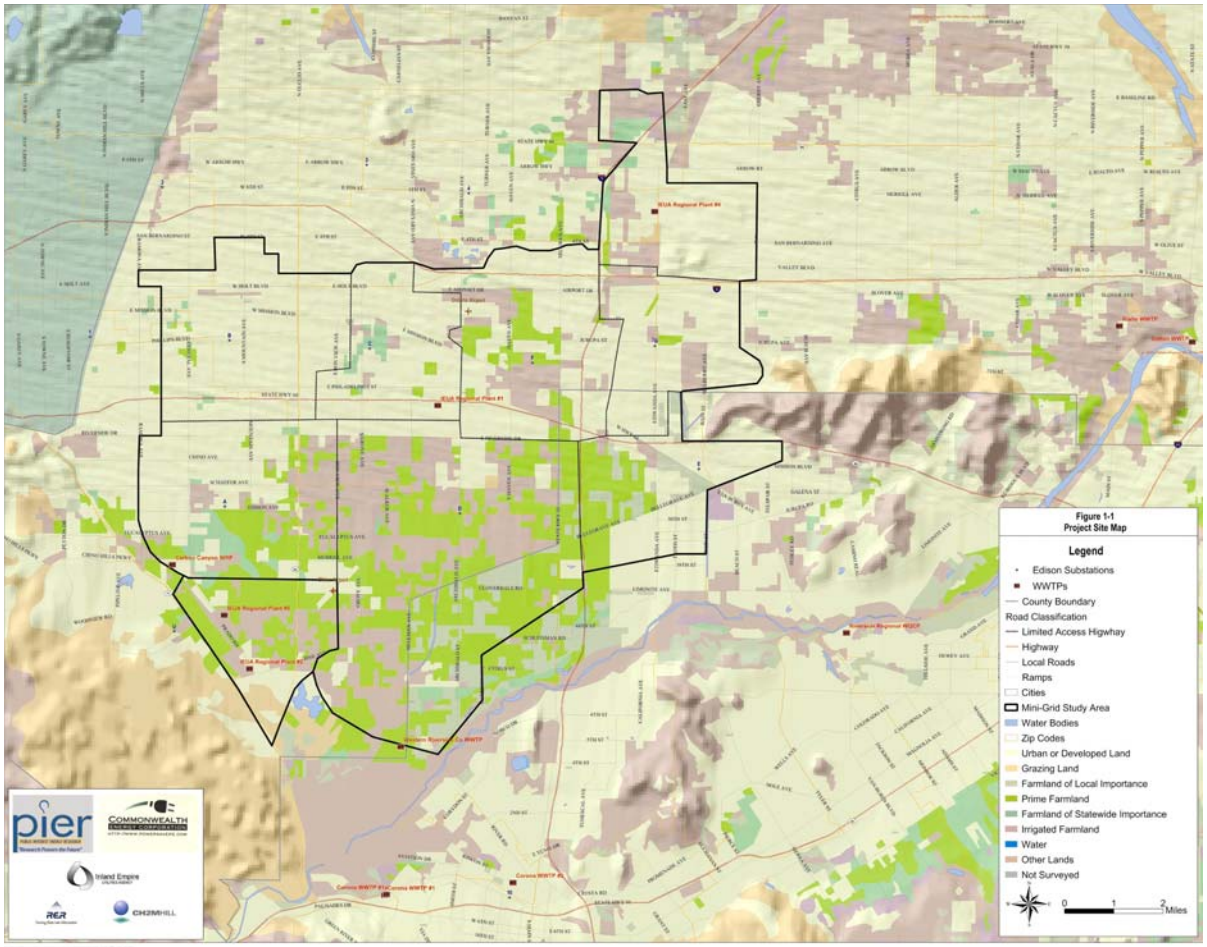
ES.1 Study Outcomes

Initial investigations by the Commerce Energy Team identified and selected one prime location within Southern California that satisfied these initial requirements. This local area was generally referred to as the Chino Valley Basin. The Chino Basin is rich in PV and biogas resources. Moreover, it is a rapidly growing area with substantial and increasing

electrical loads. The underlying goal of the Commerce Energy PIER Renewables Mini-Grid Program is to identify potential Building Integrated PV (BIPV) and biogas energy projects, bring innovative technologies and business practices to these projects, assess the benefit to the local electricity distribution system (the "mini-grid"), and then use the findings to develop a business model for siting cost-effective, renewable energy projects.

The Commerce Energy Team conducted an inventory of the biogas and non-residential BI-PV resources within the Chino Basin study area. This was refined using information on Southern California Edison's T&D system to establish the Chino mini-grid area.
The map in Figure ES-1 identifies the final selected mini-grid and the electric distribution substation service zones within it.

Figure ES-1: Mini-Grid Map



The current combined technical potential in the mini-grid area was estimated to be approximately 600 megawatts (MW). A market potential analysis resulted in an estimate of the combined current market potential for the mini-grid in the range of 4.6 MW to 8.4 MW

with an expected value of 5.3 MW. The expected value was estimated to grow to nearly 28 MW by 2012. In the early years the market potential is dominated by LFG. However, by 2012 the market potential is dominated by the non-residential Building-Integrated Photovoltaic (BI-PV) potential. In order for more of the technical potential to be realized within the mini-grid, many market barriers will need to be overcome. New ownership models, greater publicly funded incentives and educational programs, and the development of environmental emissions credit markets can have an effect on market adoption.

Power flow modeling of the mini-grid's electrical T&D system showed that there were significant equipment upgrade deferral benefits to be had as a result of the expected market potential for the renewable resources. These benefits increased significantly when the high end of the market potential was modeled. Other T&D system benefits such as voltage and Volt-Ampere Reactive (VAR) support were found to be very small.

The economic and environmental benefits associated with the renewable generation potential have been found to be specific to the mini-grid. The Chino Basin has considerable ground water contamination and air pollution directly resulting from dairy cattle waste. Full development of the renewable distributed generation resources has the potential to improve environmental management within the mini-grid. The development of renewable energy credit markets would help stimulate the development of the mini-grid.

Because the technical potential can be so large within the mini-grid area, as demonstrated in the Chino mini-grid, some means of prioritizing the finite available public funds will be necessary to optimize the public benefits. The demonstration project prioritization phase of the Commerce Energy program has created a mechanism that can be replicated and provide this needed prioritization of public funds. By identifying all the relevant criteria and providing each with a numeric weighting factor, all future renewable generation projects within a mini-grid can be scored and prioritized to optimize their public benefit.

ES.2 Study Conclusions and Recommendations

The Program Planning and Analysis Project developed an approach for tailoring resource development within a mini-grid to help meet the local needs for electric generation, T&D reliability and environmental preservation. The approach consists of the following five elements:

- Identification of candidate study area
- Inventory of renewable resources
- Assess market potential
- Assess T&D grid impacts of fully realized mini-grid

- Prioritization of renewable DG projects within mini-grid

This approach can be replicated in other locations throughout California. The area studied in this project has an abundance of biogas (landfill (LF), wastewater treatment (WWT), Dairy waste and food waste) and PV resources. It was found that the combination of biogas and non-residential BI-PV electric generation produces an excellent match to the local electric demand profile.

It is expected that the mini-grid concept will become more viable as green tag and greenhouse gas (GHG) credit markets evolve. Other financial market barriers can be addressed through continued public funding and legislative action. New ownership models similar to the one being tested by Commerce Energy and Inland Empire Utility Agency (IEUA) can also remove market barriers.

Further research, such as that being performed under the Commerce Energy Program, can improve the cost effectiveness of renewable distributed generation suitable for use in a mini-grid. However, there is a need for further research on distributed generation (DG) impacts to the local T&D system to ensure that system reliability is not jeopardized.

For a mini-grid to be fully realized, an unprecedented level of cooperation between the local T&D owner, the State and local government agencies is required. These market actors must work together during all phases of the process to ensure that all the benefits of the mini-grid are achieved. This programmatic approach requires a champion and the Energy Commission is the logical choice to fill this roll.

1

Introduction to the Commerce Energy Program Project 1.1 – Program Planning and Analysis

In June 2001, the Commerce Energy Team was awarded a programmatic contract under the California Energy Commission's Public Interest Energy Research (PIER) Program to conduct research on strategies for making renewable energy more affordable in California. The Commerce Energy approach involves assessing the combined potential of biogas and photovoltaic (PV) resources in a defined study area and identifying how these resources could be developed in a complementary and cost-effective manner. The Commerce Energy Team conducted this research in a real world setting so that the findings could be applied elsewhere in California and thereby benefit more California ratepayers. The local area Commerce Energy selected for its renewable energy research activities is the Chino Basin, referred to in this report as the "study area."

1.1 Background and Overview

The Chino Basin is rich in PV and biogas resources. Moreover, it is a rapidly growing area with substantial and increasing electrical loads. The underlying goal of the Commerce Energy PIER Renewables Mini-Grid Program is to identify potential Building Integrated PV (BIPV) and biogas energy projects, bring innovative technologies and business practices to these projects, assess the benefit to the local electricity distribution system (the "mini-grid"), and then use the findings to develop a business model for siting cost-effective, renewable energy projects. A description of the Commerce Energy PIER Program, including the results of some of the work undertaken to date, is presented in the project website: http://www.pierminigrid.org.

An important element of the Commerce Energy PIER Renewables Mini-Grid Program is to identify candidate demonstration projects within the Mini-Grid study area that advance the understanding of the use of building integrated PV and biogas resources to reduce the need for improvements to the existing study area electrical power distribution system.

The work summarized in this report is the culmination of all previous work on the project. It includes inventory work associated with the Agricultural Database Development, the Sewage Treatment Plant Database, the Agricultural and Food Processing Waste Database, and the

Photovoltaic (PV) Database. It brings together results of collecting and analyzing the T&D information in the Chino Basin and the efforts to define the market potential of the renewable resources identified in the Mini-Grid. The overall result is the identification and prioritization of renewable energy projects that will enhance the Mini-Grid and advance the development of renewable energy projects in California. The results of earlier tasks can be found in the previous reports including the following Project 1.1 report deliverables which are all available on the project website listed above:

- 1.1.1 - Review Previous Renewable Resource Assessments for California and Southern California and Define the Mini-Grid Study Area
- 1.1.2 - Develop Animal Waste and Food Processor Database
- 1.1.3 - Develop Landfill Database
- 1.1.4 - Develop Sewage Treatment Plant Database
- 1.1.5 - Photovoltaic Resource Assessment
- 1.1.6 - Define the Mini-Grid Study Area
- 1.1.7 - Assess the Biogas and PV Market Potential within the Mini-Grid
- 1.1.8 - Develop Biogas and PV Resource Generation Profiles
- 1.1.9 - Conduct Mini-Grid Power Flow Analysis
- 1.1.10 - Prepare a Prioritized List of Pilot Projects for Biogas and PV Projects
- 1.1.13 - Development of M&E Plans

The Chino Basin is an ideal location for undertaking this effort. It has one of the largest concentrations of dairy cows in the world, with over 300,000 cows located within a 50-square-mile area and has abundant sunlight well suited for building integrated Photovoltaic systems. It is also well suited for PIER research because there are a number of willing hosts for these renewable energy projects including Inland Empire Utilities Agency (IEUA), the City of Riverside and the City of San Bernardino, and the California Department of Corrections. The renewable energy projects identified will also result in environmental, economic and T&D benefits in the study area.

1.2 Program Planning and Analysis Goals and Objectives

As stated in the Statement of Work for the Commerce Energy Program, the goals of Project 1.1, Planning and Analysis Project, are to develop a formal means of assessing the potential for meeting sub regional needs with local renewable resources for one or two areas within California, and to apply this approach to the development of biogas and solar photovoltaic generation facilities for at least one of these areas. The project will cover assessments of local energy needs, assessments of biogas and solar resources, and the evaluation of local grid conditions through power flow modeling.

The objectives of the Program Planning and Analysis project are to:

- Determine the most appropriate renewable resources in the region of interest to fully serve the electric distribution grid.
- Determine the most appropriate geographic and electric system boundaries of the electric distribution mini-grid.
- Assess the technical and market electricity potential of these identified resources within the specified markets in the mini-grid.
- Estimate the electric system public benefits of the full development of these renewable resources within the region of interest over the next 5 and 10 years.
- Identify and prioritize candidate sites to participate in the team's RD&D pilot program activities.
- Develop M&E Plans for all the projects and the program

1.3 Project Report Organization

The report is organized into an Introduction and three major sections.

Section 1, Introduction, gives background information on the Commerce Energy PIER Program, provides an overview of Project 1.1, Planning and Analysis, summarizes the project's goals and objectives and describes how the report is organized.

Section 2, Project Approach, describes the approach used to identify the Chino area Mini-Grid and analyze the role renewable energy projects could play in that Mini-Grid. This section also describes the approach used to develop the Measurement and Evaluation (M&E) Plans.

Section 3, Project Outcomes, describes the Mini-Grid study area and the renewable resources within it. The results of the resource inventories (biogas and PV) are summarized, as are the results of the T&D studies that defined the boundaries of the Mini-Grid and the potential impact of the renewable resources within it. The market potential of the non-residential BI-PV and Biogas markets are summarized. Economic, environmental and T&D benefits are presented. The T&D benefits are presented for the five and ten year planning horizons. The resulting list of Project 1.1 prioritized projects is also presented along with the program and project M&E plans to evaluate them.

Section 4, Conclusion and Recommendations presents the conclusions of the Planning and Analysis Projects, the recommendations for future program activities, the benefits to California and a summary of the results of Project 1.1, Planning and Analysis.

2

Project Approach

2.1 Initial Mini-Grid Study Area and Renewable Resource Determination

The Commerce Energy PIER Renewables Program *Planning and Analysis Project* work scope called for the establishment of an electric T&D system mini-grid in Southern California within which a market potential and grid impacts study, and a number of pilot renewable generation projects would be implemented by the Commerce Energy Team. Two of the Program's early objectives within this first Project were to assess: a) the potential for select advanced biogas and building integrated photovoltaic electric generation within a small region, and b) the impacts of the future development of these selected generation resources on the local electric utility distribution and subtransmission systems. In order to allow work on these objectives to progress in the early stages of the program, an initial determination of the mini-grid study area was required. In addition to being located in a relatively local geographical region with respect to the electric system, the selected mini-grid had to satisfy several additional criteria, including:

- A significant recoverable livestock waste resource
- A building infrastructure undergoing growth,
- A growing wastewater treatment and solid waste disposal infrastructure,
- A significant number of publicly-owned facilities, and
- An electric distribution system with significant intertie(s) to the transmission infrastructure

Initial investigations by the Commerce Energy Team identified and selected one prime location within Southern California that satisfied these initial requirements. This local area was generally referred to as the Chino Valley Basin. The map in Figure 3-1 identifies the selected initial mini-grid in a bold black area that the Commerce Energy Program described as the *Chino Basin Mini-Grid Area*. The area included, but was not limited to, the communities of Chino and Ontario. As noted previously, the initial electric transmission and distribution data collected to date indicated that the mini-grid area would focus on the portion of the initial study area that is approximately West of Interstate 215 and south of I-10. This updated focus would, by design, affect the geographical distribution of the renewable

resource information collected under most of the data collection tasks under the Program's initial Planning and Analysis Project.

Biogas Resources Inventories

Under the biogas portion of the Commerce Energy Program, resource inventories were developed in three areas. These include landfills, sewage treatment plants, and agricultural waste. In each case, the goal was to identify potential locations for demonstration projects using biogas from the three sources listed above. The highlights of the approach to conduct these inventories in each of these three areas are summarized below.

Landfills:

The process to identify suitable locations for a landfill bioreactor involved looking first at landfills in four southern California counties. This initial broad-brush approach was intended to screen out landfills that would not be suitable for developing a bioreactor. For example, landfills that were closed were eliminated as it was recognized that they could not be reopened and permitted as a bioreactor. Similarly, landfills were analyzed in terms of waste accepted and those that did not accept organic material, such as those facilities that accept only construction debris, were eliminated. Based on this initial screening, a smaller number of potentially suitable landfills were identified. The approach adopted then applied more site-specific considerations to identify those that were most favorable. The net result of this approach was that the inventory identified 33 potential hosts in southern California and then identified the top 4 sites that were to be analyzed in the prioritization task later in the project. A key consideration in this task was to identify a means to model a potential bioreactor within the Mini-Grid. As part of the landfill inventory work, a landfill located within the Mini-Grid was identified as the one to be used to model potential transmission and distribution system benefits. The Milliken landfill, located within the Mini-Grid, was selected as the location where the bioreactor was to be modeled.

Sewage Treatment Plants:

The approach in developing the sewage treatment plant inventory was to identify data to be collected for every treatment plant within the Mini-Grid. Data on each treatment plant's process and energy production/use were collected. The approach of collecting relatively comprehensive information on each plant in the Mini-Grid facilitated analysis of potential demonstration projects and subsequent tasks. It should be noted, that the sewage treatment plant inventory work was intended to identify suitable locations for demonstration projects in two areas: enhanced anaerobic digestion and gas cleaning for microturbines. In the case of the enhanced anaerobic digestion activities, the approach adopted involved analyzing treatment processes employed at each plant in order to identify those that would benefit from the deployment of thermal hydrolysis or ultrasound technologies. Special consideration was

given to plants that were representative of those found elsewhere in the Mini-Grid and in California. In the case of the gas cleaning for microturbine projects, the inventory was designed to collect information on quantities of digester gas produced and current utilization practices. This information was used in subsequent tasks to identify and formulate demonstration projects.

Agricultural Waste Inventory:

As noted previously, large numbers of dairy cows are located in the Chino Basin. The approach adopted to inventory this potential biogas resource involved the modeling of biogas production rates for various size herds of dairy cows and the identification of the location of individual dairy operations. These two sets of data were then merged using a geographic information system to inventory both the quantity of manure produced as well as the amount that could be used for energy production. The inventory approach resulted in the preparation of maps and Excel databases used in subsequent phases of the project. Another element of the agricultural waste inventory was a review conducted of food processing facilities. The approach in this portion of the project was to use discharge permit information to identify food processing facilities within the Mini-Grid. The identified facilities were then contacted to gauge their interest in participating in the Commerce Energy PIER Program. The results of the dairy waste and food processing facility analyses were presented in the Inventory Report.

PV Resource Inventories

The development of the non-residential PV resource inventory within the mini-grid started with the determination of available area and ended with the assessment of the technical potential for BI-PV generation. Technical potential is defined in this context as the total system capacity in kW if all technically feasible BI-PV opportunities were utilized (i.e. a measure of technology deployment which meets the energy needs of the mini-grid under the assumption that no economic barriers exist). This assessment of BI-PV technical potential in the mini-grid covers rooftop, awning, parking lot shade structure, and other shade structure applications. The steps involved in estimating BI-PV technical potential were as follows:

- First, the number of non-residential public facilities and private sector establishments were estimated.
- Next, building energy usage and availability of area for BI-PV were explored at the building-specific level and used to estimate BI-PV system sizes necessary to offset 100% of building energy consumption.
- The BI-PV technical potential was then derived on a building type basis through the evaluation of the total floor area and the energy consumption per facility. Quantities of public facilities and private sector establishments were then combined

with estimates of average area available per building and with BI-PV system sizing factors to yield estimates of BI-PV technical potential for the mini-grid area.

Each of these steps is described in more detail below.

Estimating the Number of Establishments:

The first step in creating an inventory of photovoltaic technical potential was to determine the amount of public and commercial facilities within the target area of the study. Once the focus area zip code range and the definition of a public and commercial facility by SIC code and by building type were made distinct, a list of public agencies and facilities was created through a compilation of databases. In addition, the number of public facility buildings that exist at each public facility was determined, since many of them have more than one building per facility.

Estimating Energy Usage:

Data from the US Census Bureau were used to identify private sector establishments within the mini-grid study area. These *County Business Patterns* data include information on both the number of establishments and the total employment for particular business types by zip code area. Estimates of Energy Use Intensities (EUIs) were combined with the floor space results to calculate estimates of total annual electric energy consumption.

Estimating Technical Potential:

To develop the photovoltaic technical potential for the target area within the greater Chino Basin, each potential photovoltaic system area was addressed separately then as a whole. Furthermore, two types of photovoltaic technologies were addressed in estimating the technical potential; crystalline photovoltaic cells and amorphous photovoltaic cells. To estimate technical potential it was necessary to estimate PV *system* capacity corresponding to the available installation area. This methodology resulted in producing the average size of a photovoltaic power generation system needed to offset 100% of electric energy consumption that each building type could possibly house if all of the available area was utilized for photovoltaic arrays. To estimate the total Building-Integrated Photovoltaic (BI-PV) potential within the targeted area for public facilities, parking lot shade structures and awnings on the south side of the facilities were considered as available area for photovoltaic arrays. Also included as additional area were potential BI-PV shade structures, entry canopies, and direct-current (DC) PV applications. The type of roof a potential BI-PV facility had was taken into consideration as a solar siting concern as well.

2.2 Electric T&D Boundaries within the Mini-Grid Study Area

In order that boundaries of the electric transmission and distribution (T&D) system could be determined, a database of the components of the T&D system within the Chino Basin needed to be developed. This was performed in cooperation with Southern California Edison (SCE). The components necessary to determine the boundaries included the following:

- The general locations of the distribution level substations (66 kV stepping down to 12 kV).
- The geographic layout of the 12 kV feeders radiating out from each of the substations.
- Shunt, switch and fuse locations, and
- Maps of the locations and layout of each of the components, which were provided by SCE.

Once the substation and feeder database was developed, the locations of the BI-PV and biogas resources were laid out relative to the T&D components. The boundaries needed to contain entire feeder circuits and associated components at a minimum. When ever possible, entire distribution substations were included.

2.3 Market Potential Assessment of Mini-Grid Renewable Resources

One of the principal objectives of Project 1.1 is to estimate the quantity of non-residential renewable energy capacity that can be expected to influence future electrical distribution infrastructure operations and potential expansion requirements within the Program mini-grid area over a ten year study period beginning in 2003 and ending in 2012. These expected quantities of renewable generation are referred to as the market potentials of these technologies. Market potential represents a level of technology deployment based on an assumed combination of conditions influencing the costs, benefits, market/deployment barriers, and perceptions of the technology.

The difference between market potential and technical potential is that market potential is constrained not only by technical factors, but also by economic, market, and other human factors. An intermediate result in the market potential analysis is economic potential. Economic potential refers to the portion of technical potential that could be developed cost-effectively.

Market potential represents a subset of economic potential, which in turn represents a subset of technical potential. Estimation of market potential is therefore accomplished sequentially. The analysis began with technical potential estimates as discussed in Section 2.1. This

Section discusses first the development of economic potential, which takes into account the cost effectiveness of the technology, and subsequently the development of market potential, which takes into account other possible economic barriers to adoption of the technology.

Economic Potential Analysis

Analysis of the financial viability of renewable energy system deployment constitutes a critical step in the assessment of market potential corresponding to a given quantity of technical potential. This analysis consisted of the following steps.

- First, the financial performance of specific project prototypes is estimated in terms of internal rates of return (IRR).
- Second, the minimum acceptable project financial performance is expressed in terms of a distribution of hurdle rates.
- Finally, the project financial performance estimates and investor financial performance requirements are combined in a calculation of acceptance rates representing the portion of technical potential meeting or exceeding the minimum requirements of prospective investors in these renewable energy systems.

Each of these is discussed in more detail below:

Prototypical Project Financial Performance

The overall financial performance of an energy project can be summarized using any of a large number of possible metrics, including IRR, simple payback, or levelized cost of energy. For this analysis, the IRR was selected as the measure of project financial performance. The IRR is defined as the discount rate corresponding to a net present value of discounted cash flows equal to zero, and it reflects the influence of numerous, varied financial parameters for which values must be assumed.

In the context of this market potential assessment project, these financial parameters can be broadly classified into three groups: fixed parameters, variable parameters, and "scenario-based" parameters. Fixed financial parameters are those for which a single value was assumed regardless of the year of installation or scenario. In this study, examples of fixed financial parameters include inflation rate and marginal tax rates. Variable financial parameters are those for which values were assumed to vary depending on installation year. In this analysis, which covered installations occurring from 2003 through 2012, an example of a variable financial parameter is the Federal Stimulus Depreciation Deduction. Estimates of economic and market potential of emerging renewable energy technologies are subject to considerable uncertainty. Under these circumstances, presentation of results in terms of expected values and corresponding ranges may enable more meaningful interpretation of results. For this analysis, expected economic and market potential results are augmented

with results for *low-potential* and *high-potential* scenarios. The bases of the three scenarios are summarized in Table 2-1.

Table 2-1: Description of Low-, Expected-, and High-Potential Scenarios

Scenario	Description
Low Potential	Estimated potential based on conservative estimates of the values of financial and market parameters that yield estimates on the lower side of possible outcomes.
Expected Potential	Estimated potential based on best guesses of the values of financial and market parameters.
High Potential	Estimated potential based on charitable estimates of the values of financial and market parameters that yield estimates on the higher side of possible outcomes.

Required Project Financial Performance

The conversion of technical potential into economic potential was accomplished using information from a previous study on required rates of return (i.e., hurdle rates) conducted by RER for the Energy Commission.[1] The hurdle rate distributions developed in that study for site owners, developers, and lenders were adjusted to reflect current market conditions using the approach recommended in the study. That is, hurdle rate distributions were directly adjusted for the difference in the prime rate between the study period (1989) and the current year.

The mean required rate of return used was just under 14% in nominal terms. As indicated in the RER study, this rate applies reasonably well to all three classes of decision-makers: site owners, lenders, and developers. As a result, it is used for all prototype analyses.

Calculation of Economic Potential

IRR results yielded by cash flow models represent financial performance for particular sets of conditions, or prototypes. Numerous project prototypes were defined to capture effects of variability in such factors as retail utility rates, equipment capital costs, and availability of tax and rebate program support initiatives. Whether or not a prospective project will be judged financially acceptable depends on the hurdle rate employed by a particular financial decision-maker. Individuals and organizations employ a wide range of investment decision hurdle rates, as described above.

The calculation of economic potential for each prototype in this analysis entailed two steps. First, the prototype IRR was used in combination with the hurdle rate distribution to estimate

[1] Regional Economic Research, Inc., "Estimation of Hurdle Rates Applicable to Energy-Related Investments," June 25, 1989.

an acceptance rate. Second, the economic potential was calculated as the product of the net technical potential corresponding to the prototype and the acceptance rate for the prototype.

Market Potential Model Overview

Results of the financial analysis were combined with technical potential results in the calculations of the economic and market potential. The general form of the market potential model is illustrated in Table 2-2. Gross technical potential estimates are known from results of Program Planning and Analysis Project Tasks 1.1.2 through 1.1.5. Net technical potential at the start of year one was also assumed to be a known quantity. In particular, it is the gross technical potential less the quantity of renewable energy system capacity that is currently deployed. This latter quantity is simply the cumulative market potential at the beginning of year one.

Table 2-2: Illustration of Market Potential Model

Year	Gross Tech Potential Start of Year (Tg, kW)	Net Tech Potential Start of Year (Tn, kW)	Acceptance Rate (%)	Economic Potential During Year (E, kW)	Incremental Market Potential During Year (Mi, kW)	Cumulative Market Potential End of Year (Mc, kW)
1	Tg_1	Tn_1	A_1	E_1	Mi_1	Mc_1
2	Tg_2	Tn_2	A_2	E_2	Mi_2	Mc_2
3	Tg_3	Tn_3	A_3	E_3	Mi_3	Mc_3

The Commerce Energy PIER Program will directly influence the quantity of non-residential renewable energy system capacity deployed within the Chino Basin mini-grid. This identified capacity contributes directly to incremental market potential. Additional market potential is calculated as the product of market penetration rate and remaining economic potential.

2.4 Economic and Environmental Benefits of Mini-Grid Renewable Resources

Though not explicitly targeted to be quantified, the economic and environmental benefits of renewable resources within the mini-grid were taken into consideration.

Economic Benefits

The economic benefits associated with the biogas and BI-PV resources within the mini-grid area played a roll in the market potential assessment as well as the final Commerce Energy Program prioritization of candidate renewable generation facilities.

In the market potential assessment, an evaluation of the economic potential for the various resources was performed. This evaluation was from the facility developer's perspective. The direct economic benefits associated with the development and use of biogas and BI-PV were assessed. The prioritization process considered a benefit cost ratio as one of the criteria. This ratio was the present worth of the revenue stream divided by the rough order of magnitude of the project cost.

The economic benefits to the electric grid were also taken into consideration through the prioritization of candidate renewable generation facilities. Grid impacts, in the form of substation deferrals, were used as one of the several criteria for evaluating each project.

Environmental Benefits

The environmental benefits associated with the biogas and BI-PV resources within the mini-grid area were identified in the market potential assessment and where they had a direct impact on the facility developer they were quantified in an economic sense. These benefits took the form of avoided cleanup and abatement costs. They also took the form of green tags or renewable energy credits. The avoided cleanup and abatement costs were primarily associated with groundwater contamination. The green tags or RECS addressed the air quality benefits associated with renewable energy generation.

2.5 Estimation of Future Mini-Grid Renewable Resource T&D Public Benefits

The electric transmission and distribution (T&D) system public benefits that could be accrued by the realization of the mini-grid renewable resource market potential were estimated as part of this project. The methodology involved first identifying the T&D system components in and around the initially identified mini-grid study area. Next, a base case power flow model was developed from which the impacts of the renewable resources could be evaluated under differing penetration scenarios. Finally, the modeled T&D impacts were quantified.

T&D System for Mini-Grid

The method of estimation required that detailed information of the electric T&D system within the Chino mini-grid area be collected. These data were subsequently used to develop a power flow model of the T&D system for the purposes of estimating the potential impacts of developing biogas and BI-PV distributed generation within the non-residential sector of the mini-grid. The power flow modeling, completed under Task 1.1.9 of the Program, compared a base case scenario to an estimate of the market potential of affordable renewable distributed generation.

A local mini-grid electrical T&D system database was developed in Task 1.1.6. The resulting local T&D system database provided representative electrical characteristics of the local SCE substations and distribution feeders serving the local mini-grid area, and was developed using reasonable assumptions and peak load projections for 2003 for the mini-grid area.

The combination of substations and feeders provided a resource mix that made it possible to study a rich combination of renewable distributed generation in mini-grid market assessment performed in Task 1.1.7 and the power flow modeling performed in Task 1.1.9.

Base Case Development

The next step in estimating the T&D public benefits of the mini-grid was to develop a base case load flow model of the T&D system. The local mini-grid database contains appropriate electrical parameters and load distribution suitable for inserting into a local T&D load flow model, expanding to future years 2007 and 2012, and performing detailed power flow, voltage and var calculations of the projected future local mini-grid T&D system with and without renewables in Task 1.1.9.

The T&D assessment performed in this study consisted of a bottom-up T&D impact evaluation of distributed renewable generation installed in the 12 kV distribution systems within the mini-grid area. The major impacts of installing renewable generation within the mini-grid were expected to be on the local mini-grid T&D facilities - first at the feeder level and then as penetration increases at the distribution substation level. Large penetrations of distributed renewable generation were expected to have some measurable impact on power flows in the “local” bulk 500/230 kV transmission system that serves southern California. Therefore, the plan was to model the transmission system as well as the local mini-grid system.

Estimation of Public Benefits

In this task peak and light load power flow models within the mini-grid in 2007 and 2012 were developed from the base case T&D model developed in Task 1.1.9a. These mini-grid power flow models employed in this effort were then used to compare a base case scenario (without renewables) to various estimates of the penetration of market potential of renewable distributed generation. Potential impacts on power flow, losses, voltage regulation, reliability, reverse power flow and flicker within the mini-grid due to the installation of renewables were analyzed during peak load and light load conditions, and potential T&D value determined.

The renewable distributed generation under expected, high and low penetration scenarios as well as peak and light load conditions were modeled. Mini-grid power flow results for 2007

and 2012 were developed. Corresponding impacts on mini-grid power flow, losses, voltage regulation, reliability, reverse power flow and flicker within the mini-grid due to the installation of renewables were developed and potential economic T&D public benefits calculated.

2.6 Identification and Prioritization of Candidate Renewable Generation Facilities

One of the major objectives of the Planning and Analysis Project is the prioritization of candidate sites to participate in the Commerce Energy Energy's RD&D pilot program activities. The prioritized site selection methodology is based on a set of criteria used to evaluate potential RD&D pilot projects. Originally, the set of prioritization criteria included technical attributes of the projects, and benefits to the mini-grid that would accrue from the projects. Since the establishment of those original criteria, the Commerce Energy Business Plan has been developed, and it contains both financial and non-financial decision criteria that are relevant to these renewable power projects. Therefore, key elements of the Commerce Energy Business Plan were incorporated into this analysis. The full list of criteria for evaluation of identified projects has three major groups of criteria:

- Criteria from the Commerce Energy Business Plan
- Mini-Grid Benefits
- Technical (RD&D) Attributes

The next levels of decision criteria are grouped under each of the top-level criteria. For the criteria under the Commerce Energy Business plan, both financial and non-financial criteria were developed. There are several levels of criteria sub-groups, following the general flow of the priorities stated within the Commerce Energy Business Plan itself.

Table 2-3 shows a listing of these criteria by major groups.

Table 2-3: Evaluation Criteria List

Commerce Energy Business Plan		
Non Financial		
Community Aggregation		
Near Term Targets		Areas that Commerce Energy wishes to target with projects
	Santa Monica	
	No. California Community	
	Chino	
	Ontario	
	Central Valley Community	

Table 2-3: Evaluation Criteria List (Continued)

Commerce Energy Business Plan		
Long Term Positioning		Market areas for strategic growth and positioning
	Applicability to Others in Municipal Sector	
	Applicability to Others in Agricultural Sector	
	Contributes to Renewable Resource Affordability (size, reliability, cost and dispatchability)	Stated strategic goal of the PIER program
Greenfield Development		
Green Tags		Based on the State's Renewable Portfolio Standard (RPS)
Other Benefits		
Environmental		
Power Diversity		
Power Reliability		
Credibility / Branding		Extension of Commerce Energy's name into new markets due to project
Financial		
Expected Revenue ($1,000s)		
	Direct Revenue	Directly due to the project
	Indirect Revenue	Potential from spin-off projects in the same area
Benefit/Cost Ratio		Defined as the present worth of the 15-year direct revenue stream discounted at 9% divided by a rough-order-of magnitude (ROM) cost for the project(s)
Mini Grid Benefits –From the Perspective of the Mini-Grid		
Non Financial		
New System Capacity (kW)		Amount of new system capacity in kW represented by the project(s)
Distribution System Deferral Benefit		Potential to defer building a new sub-station due to new renewable energy from project
Distribution System Cost Savings Benefit		Potential to reduce distribution maintenance costs due to reduced distribution system load
Voltage Regulation Benefits		Contribution of project to better voltage regulation in the distribution system
Line Loss Reductions Benefits		Reduced line losses from project due to on-site generation of renewable energy
Financial		
Quantifiable Benefit / Total Cost Ratio		This is benefits from sub-station deferral divided by costs to the mini-grid, such as self generation incentives
NPV of Net Benefits to Mini-Grid		This is present value of future benefits from sub-station deferral, less the self-generation incentive
Total Deferred Capital Cost		This is the total cost deferral from sub-station deferral from the project.

Table 2-3: Evaluation Criteria List - Continued

Technical Criteria	
Suitability for Demonstrating Technology	Goal of PIER program - demonstrate new technologies
Permitting Capability	Critical issue for those projects requiring permits
Statewide Applicability	Goal of PIER program - develop technologies that can be applied elsewhere in the state
Technology Risk	
Lead Time	Time horizon of project versus time horizon of PIER program funding
Match Fund Ratio	Defined as (Match Funds)/(PIER + Match funds)
Host / Developer Economics and Financing	
Program Linkage	

A weighted-objectives hierarchy model was used as a decision tool for prioritizing projects along these criteria. The analysis utilized software to build an objectives hierarchy model. Given a goal, different criteria and attributes, and various alternatives were developed to create a decision model.

Once the framework was entered into the decision model, different weights were assigned to the criteria, the top-level goals were assigned sub-level criteria, and lowest level attributes of the various projects were scored along different scales. Scoring methods were allowed to vary for different attributes. The software normalized all scoring for each attribute, building a composite score for each project alternative that ranges between 0.0 and 1.0, with 1.0 being an "ideal project." Contributions to composite scores for each project from individual attribute scores were also analyzed, in order to understand why different projects scored higher or lower in the model.

The top-level set of priorities for this project is the three main categories of criteria; Commerce Energy Business Plan, Mini-Grid Benefits, and Technical Criteria. They were weighted as shown in Table 2-4.

Table 2-4: Top-Level Evaluation Criteria Priority Weighting

Top Level		
	Weightings	
Evaluation Criteria	Score 1-5	Absolute
Commerce Energy Business Plan	5	0.421
Mini-Grid Benefits	3	0.211
Technical	4.5	0.368
TOTAL		1.000

Finally, the scoring results were such that natural dividing points between groups ("tiers") of projects were evident for both the biogas and BI-PV projects. For both sets, projects were divided into a Tier 1 (highest priority), a Tier 2 (secondary consideration as program schedule and resources allow) and a Tier 3 (removed from consideration under the Commerce Energy PIER program). Tier 1 projects are those that warrant further funding and implementation at this time. Tier 2 projects include those that may be implemented after requirements for Tier 1 projects are met. Tier 3 projects include those that do not sufficiently meet the combined goals of Commerce Energy business objectives and the PIER program to be implemented at this time. This allows for the most appropriate concentration of available public and private resources on the highest priority projects (Tier 1 initially) in order to assure optimal program results.

2.7 Development of Project and Program M&E Plans

In order to evaluate the effectiveness of the individual projects as well as the Program as a whole, a comprehensive measurement and evaluation (M&E) plan was developed. This plan shall be used to evaluate each of the specific projects and each project's contribution to the overall Commerce Energy Program-level goals and objectives. This plan defines, for the Program-level and the distinct project objectives, specific performance metrics, data collection plans, analysis techniques, and the M&E implementation schedule.

The project-specific evaluation plans include three sections for each project:

- 1) Pilot Project Performance,
- 2) Technology Transfer and
- 3) Market Impact.

The overall Program-Level M&E Plan was structured in a fashion to determine the degree to which each of the funded projects contributed to the stated goals and objectives of the Program. The plan defines the specific performance metrics, data collection plans, analysis techniques, and the M&E implementation schedule for the Program. In addition, the Program Plan also addresses the effectiveness of the programmatic aspects (linkages) between the projects in the Commerce Energy Program in achieving their goals, as well as any linkages to the other PIER-funded Renewables Programs (i.e., programmatic contracts) that are being implemented over the same time frame.

3

Project Outcomes

3.1 Initial Mini-Grid Study Area and Renewable Resources

Determination of the Initial Mini-Grid Study Area

The Commerce Energy PIER Renewables Program *Planning and Analysis Project* work scope calls for establishing an electric T&D system "mini-grid" in Southern California within which a market potential and grid impacts study, and a number of pilot renewable generation projects will be implemented by the Commerce Energy Team. Two of the Program's early objectives within this first Project were to assess: a) the potential for select advanced biogas and building integrated photovoltaic electric generation within a small region, and b) the impacts of the future development of these selected generation resources on the local electric utility distribution and subtransmission systems. In order to allow work on these objectives to progress in the early stages of the program, an initial determination of the mini-grid study area is required. In addition to being located in a relatively local geographical region with respect to the electric system, the selected mini-grid must satisfy several additional criteria, including:

- A significant recoverable livestock waste resource,
- A building infrastructure undergoing growth,
- A growing wastewater treatment and solid waste disposal infrastructure,
- A significant number of publicly-owned facilities, and
- An electric distribution system with significant intertie(s) to the transmission infrastructure.

Initial investigations by the Commerce Energy Team identified and selected one prime location within Southern California that satisfies these initial requirements. This local area is generally referred to as the Chino Valley Basin, and includes, but is not limited to, the communities of Chino and Ontario.

Biogas Resources Inventories

Three sets of biogas inventories were assembled under this project. These include:

- Animal Waste and Food Processor Database, developed under Task 1.1.2
- Landfill Database, developed under Task 1.1.3
- Sewage Treatment Plant Database, developed under Task 1.1.4

The inventories were presented in three separate reports, each of which included an appendix containing an electronic database. A brief summary of current installations and future potential for each of these is presented below.

Animal and Food Processor Waste

Dairy manure represents a potential source of feedstock for anaerobic digestion to produce biogas for electric generation. Data collected from the Santa Ana Regional Water Quality Control Board (SARWQCB) and presented in the Dairy Operations and Food Processor Databases provide an estimate of technical potential for electric generation from dairy manure within the mini-grid for agricultural facilities.

Manure was broken into two types. The first, manure, which can be collected for digestion, is available at the milking center and from feed lanes. The second type, corral dried, is unsuitable for digestion because it is too dry, it has lost much of the volatile solids content that produces biogas and it contains relatively large quantities of soil, rock, and other material not suitable for digestion.

The Chino Basin food processing inventory identified 14 food processors as potential sources of AD-suitable waste streams. Waste stream content and biogas-producing potential varies widely. For example, some waste streams are now collected by IEUA sanitary sewers, and as a result, the solids are already undergoing AD indirectly at the waste treatment plant.

Current Potential

The current renewable resources were quantified from a technical perspective, referred to here as the current potential. The current potential is the technically feasible amount of the renewable resources that can be applied to the production of electricity. This quantity is expressed in terms of the amount of electric generation technically possible. At this stage, no economic or market conditions are taken into consideration.

Dairy Manure

For dairy manure from feed lanes and milking centers, the overall maximum capacity for energy production in the study area is a function of the ability to capture fresh manure suitable for use in wet anaerobic digestion systems. Experience shows that the maximum field capture rate is approximately 40-50 percent from the feed lanes, milking center, and other areas of the dairy. This capture rate correlates to 317 to 396 dry tons per day removed from the dairies in the study area. If this is digested to produce 70 percent methane gas, 4.9 to

6.1 megawatts (MW) of electrical power generation could result. Table 3-1 shows resulting manure capture and power production at different capture rates assumed.

Table 3-1: Current Potential for Dairy Waste

Manure amounts and Power Production at 100%, 40%, and 50% field capture rates.

	Milking Centers		Feed Lanes		Total	
Capture Rate	Dry Tons/day	Power (MW)	Dry Tons/day	Power (MW)	Dry Tons/day	Power (MW)
50%	138	2.1	258	4.0	396	6.1
40%	110	1.7	206	3.2	317	4.9

NOTE: "Corral dry" manure is not included in these numbers

Corral dry manure is not suitable for anaerobic digestion, thus energy recovery from this manure would require use of another technology such as gasification. The technical potential for gasification of corral dry manure is estimated at 0.119 MW per ton of manure. This estimate is based on 408 Btu per pound of corral dry manure, a number that can vary widely depending on the "quality" of the manure. Estimates of current technical potential are based on manure inventory estimates, which amounted to about 652,500 tons per year (TPY), produced within the study area. This would equate to approximately 80 MW of potential energy generation through gasification technology.

The actual potential power production at any given location is based on site-specific waste quantity and quality, moisture content, and operating practices.

Food Processor Waste

Based on information contained in a report prepared by the California Office of Economic Research, entitled *The California Food Processing Industry*, food processing firms are as widely scattered throughout California as the farmlands that supply them.

Areas in which California is a significant food processor on a national basis include:

- Fruit and vegetables (San Joaquin Valley, Sacramento Valley, Central Coast, Fresno County)
- Wine production (Napa, Sonoma, Stanislaus, and San Joaquin counties)
- Nuts and nut processing (Madera, San Joaquin, Stanislaus, Tulare, and Sacramento counties)
- Canned and cured seafood processing (Los Angeles, Orange, and Alameda counties)

After wine production, the manufacture of soft drink beverages is the second largest beverage employer in the state.

The Chino Basin food processing inventory identified 14 food processors in and around the study area as potential sources of AD-suitable waste streams. Waste stream content and biogas-producing potential varies widely. For example, some waste streams are now collected by IEUA sanitary sewers, and as a result, the solids are undergoing AD.

Based on the inventory report's annual waste volumes and COD or BOD levels, the technical potential for methane production from food processor waste streams is estimated at 37 MW. This estimate is based on CH2M HILL estimates for the reactivity of each of the individual facility waste streams, as documented in Table 3-2. A conversion efficiency from biogas to electricity of 33 percent was assumed.

Table 3-2: Current Potential for Food Processing Waste

Technical Potential for Identified Food Processors

		Wastewater							
Facility Name	**Waste Source**	**Volume (gal/yr)**	**BOD (mg/L)**	**COD (mg/L)**	**COD (kg/hr)**	**Reactivity (% kg/kg)**	**Methane (ft^3/hr)**	**Efficiency (%)**	**Power (kW)**
Coca Cola, USA	Blowdown, backwash, condenser discharge	6,152,497	–	162.6	114.2	90	1,270	33	111
Frito Lay, Inc.	Corn washing, corn transfer, floor washdown	83,821,957	–	2715	25979.1	75	240,829	33	20,961
Sunkist Grower's, Inc.	Equipment washdown, boiler wastewater	15,459,040	–	256	451.8	60	3,350	33	292
Haliburton International Corp.	Washing and sanitizing grinder, mixer, and utensils	62,300	–	7731	55.0	60	408	33	35
Nakano Foods, Inc.	Vinegar production, bottling, boiler blowdown	5,837,860	–	1503	1001.6	90	11,142	33	970
Arrowhead Mountain Spring Water	Softener backwash, blowdown, condensers	22,588,748	–	121	312.0	90	3,471	33	302
Ludford's, Inc.	Floor and equipment cleaning	9,200	–	3781	4.0	90	44	33	4
Coast Grain Company	Boiler blowdown and boiler condensate	66,182	–	3699	27.9	75	259	33	23
C.C. Graber	R.O. process and boiler blowdown	321,000	–	9112	333.9	60	2,476	33	216
Hallmark Meat Packaging	Paunch, stock washwater	83,044,800	–	1142	10826.2	60	80,288	33	6,988
Morgan Confection Company		3,259,610	–	5113	1902.6	90	21,164	33	1,842
Parallel Products	Process water, sludge from clarifier, excess food stock	25,560,000	1,650		7221.6	60	53,556	33	4,661
Niagara Bottling	Almost no organic waste	–	–	–	0.0	90	–	33	–
Old Rancher's Canning Company	Excess ingredient, ingredient processing, solids screened from wastewater	8,875,000	–	497	503.5	75	4,668	33	406
Total Technical Potential									**36,810 kW**
									37.0 MW

Future Potential

Consultations with dairy industry representatives suggest that development pressures in the Chino area will result in about a 50 percent reduction in the number of dairies and AU in the study area by the year 2015. Assuming all other factors remain the same, a 50 percent reduction would result in about 103 dairies in the study area. Manure production and technical potential for electricity generation will decline correspondingly. Table 3-3 presents estimates for technical potential over time for manure from milking centers, feed lanes, and corral-dry manure, based on this reduction.

The effect of community build-out on food processors in the area is unknown at this time. The future technical potential was projected as being steady through 2015.

Table 3-3 summarizes the estimated technical potential from the three sources discussed in this section. The primary determinant of technical potential is the projected decline in the Chino Basin dairy industry.

Table 3-3: Future Potential for Dairy & Food Processing Waste

Chino Basin Estimated Technical Electricity Production from Agricultural and Food Processing Wastes: through 2015 (MW a)

Source	2001/2002	2007	2012	2015
Dairy Washwater from Milking Centers	2	2	1	1
Dairy Manure from Feed Lanes	4	3	2	2
Corral Dry Manure Gasification	80	60	45	40
Food Processors	37	37	37	37
Total	**123**	**102**	**85**	**80**

When the Chino Basin is fully developed, it is anticipated that only a few dairies will remain in operation in the area. The amount of technical potential for generation from dairy manure projected at the time of full community build-out is essentially zero.

Landfill Waste

The *Inventory Report for Potential Landfill Bioreactors* provided information on landfills in a four-county area of southern California that might be selected for implementing landfill bioreactors.

Current Potential

As with the dairy and food processing waste, the current technical potential for landfill gas is the technically feasible amount of the renewable resource that can be applied to the production of electricity. This quantity is expressed in terms of the amount of electric

generation technically possible. At this stage, no economic or market conditions are taken into consideration.

Within the four-county area surrounding the study area, there are at least 16 high-potential MSW landfill sites that could enhance gas production. Based on the reported waste disposal rates at these sites, a total technical potential of 266 megawatts (MW) is estimated to be available if all were operated as bioreactors, with more power available from sites that overcome their current impediments to bioreactor operation.

The four-county area (San Bernardino, Riverside, Orange, and Los Angeles) immediately around the study area was inventoried for landfills that might be suitable host for a bioreactor. The results of this effort were reported in our *Inventory Report for Potential Landfill Bioreactors*. Seventy-one landfills were identified in the four-county area. Only existing permitted solid waste landfill sites were considered as potential sites because of the great uncertainties involved in siting and permitting new landfills.

These 71 landfills were screened using the following criteria:

- The landfills have current waste disposal facility permits.
- The landfills receive at least 10 tons per day of MSW or other biodegradable materials (that is, construction and demolition waste landfills and landfills that receive largely inert materials were not considered).
- The landfills have at least 2 years of additional permitted capacity remaining, which will allow conversion to a bioreactor during the active life of the landfill.

This process reduced the number of candidate landfills to 33. Additional data was then gathered on these landfills and attempts made to contact the owners regarding their willingness and ability to consider converting the landfill into a bioreactor. This step reduced the list of potential landfill sites further to 16. These 16 landfills are summarized in Table 3-4.

Table 3-4: Landfills with Potential for Bioreactor Facility

Landfill Name	Location	Owner	Waste in Place (tons)	Waste acceptance rate (tons/day)	Potential Power (MW)
Lancaster Landfill	Lancaster, Los Angeles County	WMI	600,000	1,000	2
Chiquita Canyon Landfill	Santa Clarita, Los Angeles County	Republic Services	7,946,076	4,900	22
Puente Hills Landfill	Whittier, Los Angeles County	LACSD	32,000,000	15,000	90
Scholl Canyon Landfill	Glendale, LA County	LACSD	16,000,000	1,300	45
Sunshine Canyon Landfill	San Fernando, Los Angeles County	BFI	3,088,000	350	9
Antelope Valley Public II	Palmdale, Los Angeles County	Palmdale Disposal Co	1,641,200	750	5
Badlands Disposal Site	Moreno Valley, Riverside County	Riverside County	5,168,932	1,500	15
Lamb Canyon Disposal Site	Beaumont, Riverside County	Riverside County	3,727,009	500	10
Blythe Sanitary	Blythe, Riverside County	Riverside County	1,350,791	100	4
El Sobrante	Corona, Riverside County	Western Waste Industries	8,000,000	4,900	22
Victorville	Victorville, San Bernardino. County	San Bernardino County	2,791,235	800	8
Barstow Disposal Site	Barstow, San Bernardino. County	San Bernardino County	1,344,603	2200	4
Colton Disposal Site	Colton, San Bernardino. County	San Bernardino County	5,166,514	800	15
Fontana (Mid-Valley)	Fontana, San Bernardino. County	San Bernardino County	2,800,000	3,000	8
San Timoteo	Redlands, San Bernardino. County	San Bernardino County	880,000	500	2
Fort Irwin Sanitary Landfill	Fort Irwin, San Bernardino. County	U.S. Army	1,704,564	25	5
		TOTAL TECHNICAL POTENTIAL (MW)			**266**

Note: Sites in bold are top-ranked sites.
MW = megawatt.

Sewage Treatment Plants (STPs)

There are 242 STPs in California with design average annual flows of 1 million gallons per day (mgd) or more. Anaerobic digestion is a process that has been used at STPs for more than 100 years. However, advances in the understanding of the anaerobic digestion process have led to improved operation of the digestion process and development of new technologies that enhance digestion and improve performance in terms of gas production by up to 50 percent. Advances in generation systems that can run on digester gas, such as microturbines, are improving the feasibility of renewable energy generation, particularly at smaller STPs.

Within the study area there are 11 STPs currently in operation:

- Inland Empire Utilities Agency Regional Plant 1 (RP-1)
- Inland Empire Utilities Agency Regional Plant 2 (RP-2)
- Inland Empire Utilities Agency Regional Plant 4 (RP-4)
- Inland Empire Utilities Agency Regional Plant 5 (RP-5)
- Carbon Canyon Wastewater Reclamation Facility (CCWRF)
- City of Corona Plant 1A and 1B
- City of Corona Plant 2
- Western Riverside County Wastewater Treatment Plant (Western Riverside)
- Riverside Regional Water Quality Control Plant (Riverside)
- Rialto Wastewater Treatment Plant
- Colton Wastewater Treatment Plant

Only six have the biosolids handling facilities that can benefit from advanced digestion processes. Of these plants, five are operated by Inland Empire Utilities Agency (IEUA) and two by the City of Corona. Several of the plants do not have digestion facilities onsite; the solids are sent to another plant for stabilization. RP-4 solids are sent to RP-2. CCWRF solids are sent to RP-1. City of Corona Plant 2 solids are sent to the City of Corona Plant 1. One new plant, RP-5, is under construction and design parameters will be used to determine potential future energy production at this plant. Western Riverside uses aerobic digestion, rather than anaerobic digestion. Information on all study area STPs is provided in the database in Appendix A of the *Inventory Report for Sewage Treatment Plants* for use in determining energy usage.

The *Inventory Report for Sewage Treatment Plants* presents the data collected for sewage treatment plants (STPs) as part of the effort to enhance energy recovery through optimization of anaerobic digestion and the application of microturbines.

Current Potential

To estimate current technical potential for generation from enhanced biogas production and utilization, a baseline inventory of existing biogas production capability for the IEUA plants RP-1, RP-2, RP-4 and RP-5 plants was taken for 2002. Then, two increases were applied: an increase due to projects that enhance gas production, such as ultrasound treatment or thermal hydrolysis.

A further increase (**in addition**) to enhanced gas production, that would come from projects for enhanced energy recovery, using bottoming cycles such as organic Rankine engines or absorption chillers.

The technical potential, in this case, is the **incremental** generation above the baseline (in kW) that is derived from these projects. The current technical potential is shown in Table 3-5 below:

Table 3-5: Current Potential from STP Projects

IEUA Regional Plants #1,2,4 and 5

Scenario	(kW)
Enhanced Gas Production Only	
Base Generation	2,581
With Enhanced Gas Production	4,130
Difference (Technical Potential due to enhanced gas production only)	**1,549**
Enhanced Gas Production + Additional Energy Recovery	
Base Generation	2,581
With Enhanced Generation AND Additional Energy Recovery	4,891
Difference (Technical Potential due to enhanced gas production AND additional energy recovery	**2,309**

Future Potential

Projected growth data from IEUA was used to calculate a 6.7% annual growth rate predicted between 2002 and 2012 for waste at STPs. Based on this growth rate, Table 3-6 shows estimates for technical potential for additional generation stemming from enhanced gas production and energy recovery projects at STPs in the Chino Valley Study Area.

Table 3-6: Future Potential from STP Projects

Projected Technical Potential (kW) From STP Projects Through 2012

Scenario	Year		
	2002	2007	2012
With Enhanced Gas Production	1,549	2,142	2,961
With Enhanced Generation AND Additional Energy Recovery	2,309	3,193	4,416

PV Resource Inventories

The study of technical potential of photovoltaic technologies included summarizing an inventory of current installations and estimating future potential. Each is briefly described below.

Current Potential

The inventory of technical potential for both the public and private sectors is summarized in Table 3-7. As shown, the results are categorized for crystalline and amorphous photovoltaic technology. Crystalline technology contributes two-thirds of the total potential or roughly 526 MW, distributed mostly (92%) among private establishments.

Table 3-7: Summary Results – Public and Private Sector Technical Potential

Nonresidential Sector	Number of Facilities/ Establishments	Crystalline (kW)	Amorphous (kW)
Public Facilities	240	42,096	21,048
Private Establishments	3,857	483,943	241,972
Total	**4,097**	**526,039**	**263,020**

Other key findings include the following:

- Within public facilities potential, the dominant building type was Miscellaneous, and the dominant application was Covered Parking (contributing roughly 50% of Miscellaneous potential).
- Within private establishment potential, the dominant building type was Warehouse and Storage, and the dominant application was Covered Parking.
- Within private establishment potential, four building types contributed more than 70,000 kW to crystalline technical potential: Warehouse and Storage, Manufacturing, Service and Mercantile.
- With the exception of Manufacturing and Warehouse and Storage, covered Parking is the dominant application for all building types in private establishment potential.

These results can be seen in Table 3-8 and Table 3-9 below.

Table 3-8: Crystalline Technical Potential for the Total Public Facilities (kW)

Building Type	Roof Mounted	Awning Mounted	Covered Parking	Open Space	Total kW
School	3,063	1,341	7,787	473	12,665
College	253	45	551	27	875
Hospital	278	161	1,193	60	1,692
Office	854	610	3,941	240	5,644
Miscellaneous					
Very large	8,558	1,048	9,627	40	19,273
Other	718	142	808	280	1,947

Table 3-9: Crystalline Technical Potential for Private Sector (kW)

Building Type	Roof Mounted	Awning Mounted	Covered Parking	Open Space	Total kW
Education	371	64	1,131	48	1,614
Food Service	4,342	603	26,763	503	32,211
Health Care	1,468	658	6,290	451	8,867
Lodging	773	131	2,728	32	3,664
Manufacturing	49,646	3,212	45,827	1,663	100,349
Mercantile	20,582	1,653	48,115	1,061	71,411
Office	4,263	1,559	19,674	1,261	26,757
Other	6,216	365	13,644	267	20,493
Public Assembly	1,095	109	9,124	37	10,364
Religious Worship	1,569	175	12,173	70	13,987
Service	24,361	1,676	54,812	1,129	81,978
Wrhse & Storage	69,635	3,698	36,866	2,049	112,248

Future Potential

The future technical potential for both crystalline and amorphous photovoltaic technologies for BI-PV applications within the mini-grid was estimated by multiplying the accumulated yearly percent of change of energy consumption as forecasted by the California Energy Commission[1] for 2007 (115.4%) and 2012 (124.1%) by the existing 2002 BI-PV technical potential.

[1] California Energy Commission 2002-2012 Electricity Outlook Report February 2002 pg. 21

Results are summarized in Table 3-10. In the mini-grid market potential assessment, discussed later in Section 3.3, these technical potential results are combined with market penetration estimates and other market data and assumptions to estimate market potential given the existence of technical (e.g., available implementation area), economic (e.g., capital cost of photovoltaic systems, systems owner investment hurdle rates), and market (e.g., willingness to use new technology) barriers to BI-PV deployment.

Table 3-10: Technical Potential – 5- & 10-Year Forecasts

Year	Public Facilities			Non-residential Private Sector		
	Number of Facilities	Crystalline (kW)	Amorphous (kW)	Number of Establish-ments	Crystalline (kW)	Amorphous (kW)
2002	240	42,096	21,048	3,857	483,943	241,972
2007	277	48,579	24,290	4,451	558,470	279,235
2012	298	52,242	26,121	4,787	600,573	300,287

3.2 Electric T&D Boundaries Within the Mini-Grid Study Area

An electric T&D system "mini-grid" was established in Southern California, for use in a market potential and grid impacts study. Criteria for the region are presented in Section 3.1 . A prime location within Southern California satisfying these requirements was selected. This local area is generally referred to as the Chino Valley Basin. Initial electric transmission and distribution data collected indicated that the study of the mini-grid area should focus on the portion of the Chino Valley Basin that is approximately West of Interstate 215 and south of I-10.

The Chino Basin mini-grid area is served by nine (66 kV stepping down to 12 kV) substations and 72-twelve kV feeders as shown in Figure 3-1. An outline of the mini-grid map, shown in Figure 3-2 provides an overview of the influence zones served by the nine 66/12 kv substations. Both transmission and distribution system information have been developed for the local Chino Basin mini-grid area.

Figure 3-1: Commerce Energy Renewables Mini-grid Map

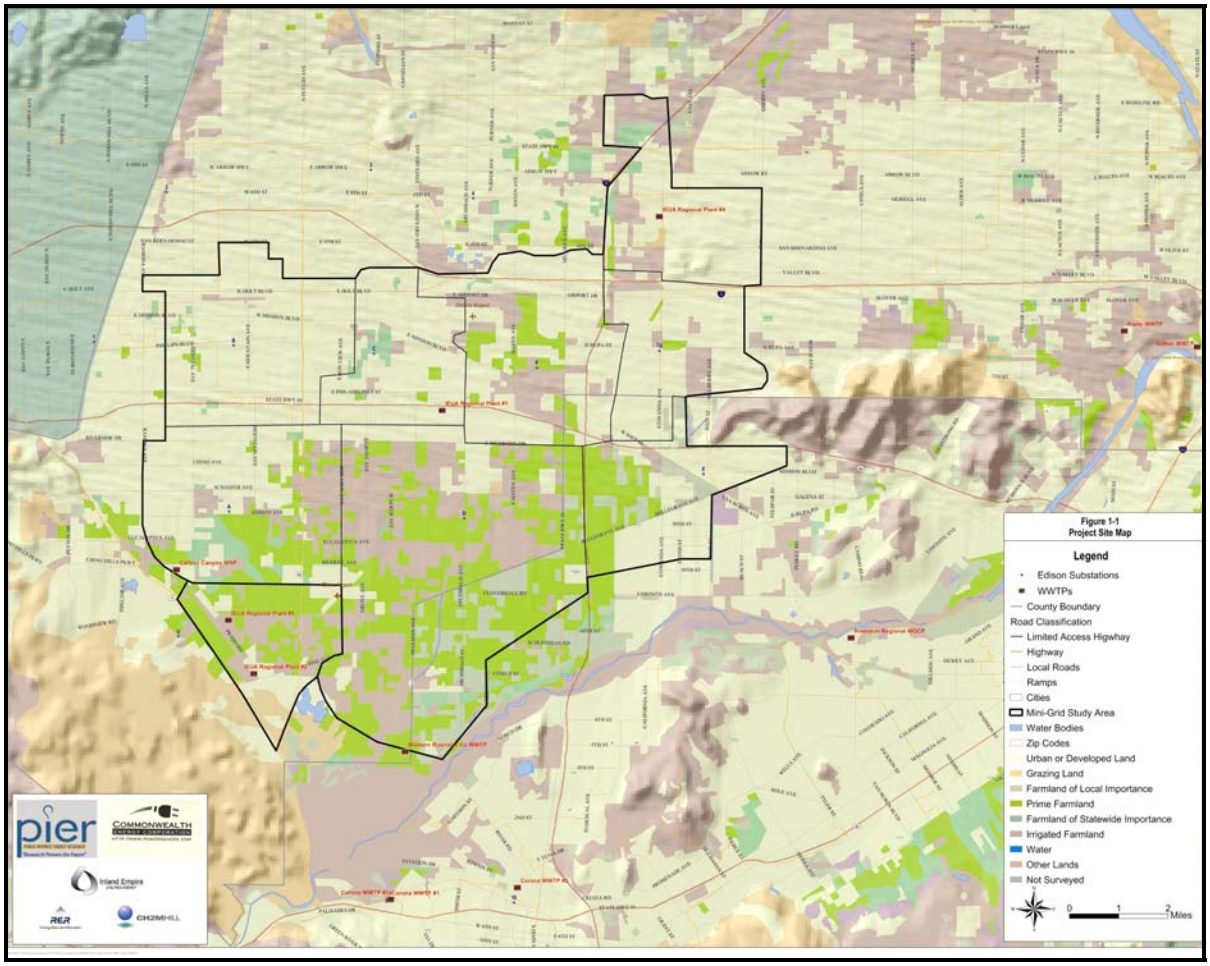
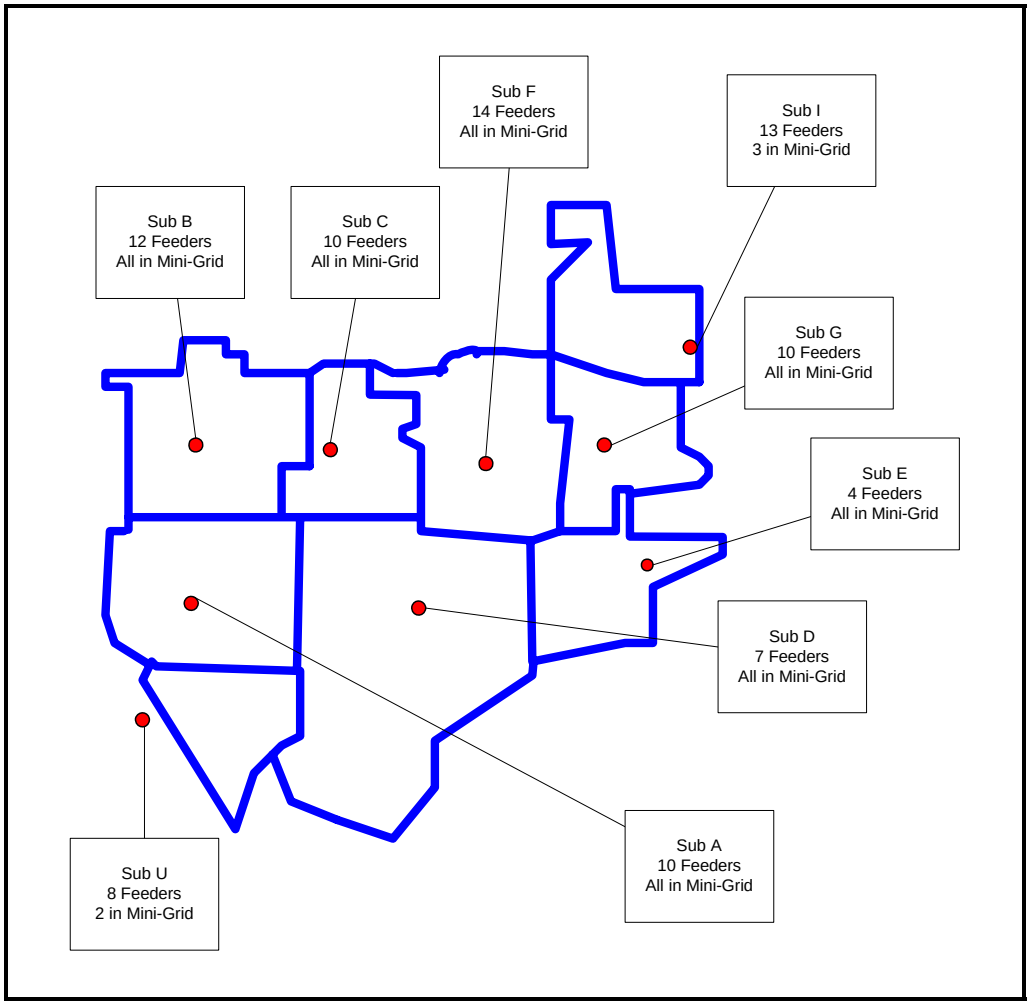


Figure 3-2: Overview of Local Chino Basin Mini-Grid



3.3 Market Potential Assessment of Mini-Grid Renewable Resources

This assessment addressed the market potential of nonresidential BI-PV, agricultural and food processing waste biogas, incrementally developed generation capacity from enhanced wastewater treatment biogas, and landfill bioreactor gas (LFG) resources over the period of 2003 through 2012.

Summary of Combined Market Potential by Resource

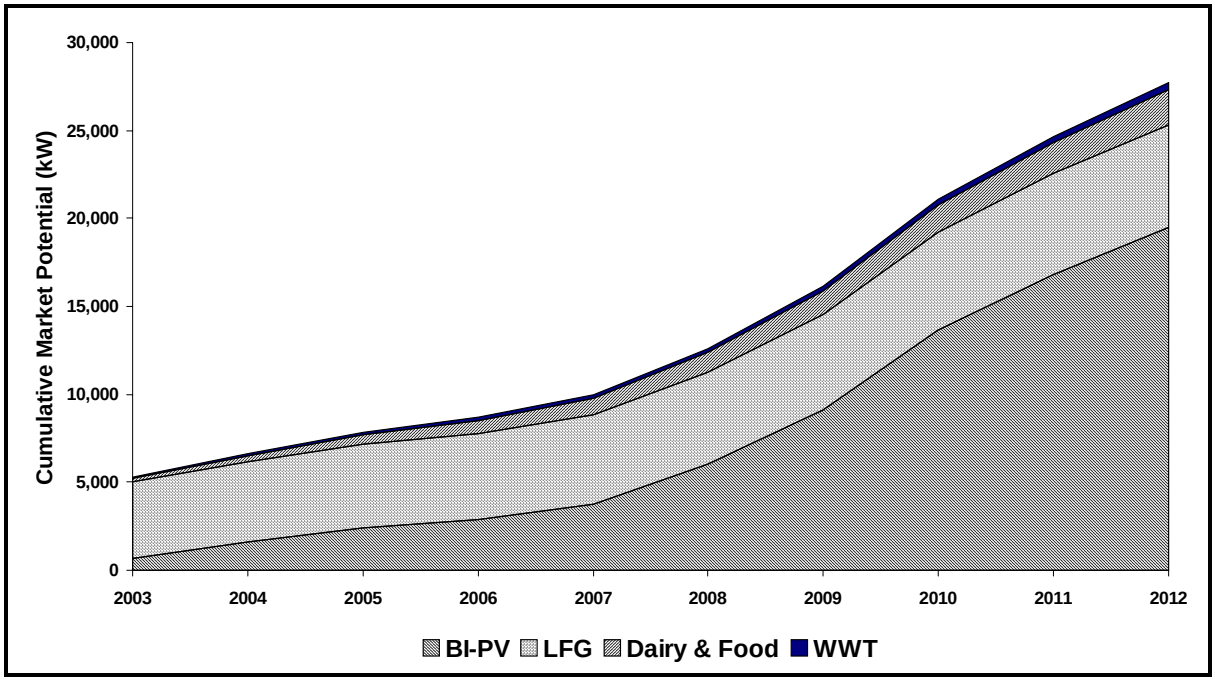
The combined expected market potential for these four nonresidential renewable resources within the Commerce Energy Program mini-grid is approximately 5 MW in 2003 and increases to nearly 28 MW by 2012. In the early years, the combined potential is dominated

by LFG. By the end of the planning horizon, the BI-PV potential dominates the combined potential. Table 3-11 and Figure 3-3 present the results.

Table 3-11: Expected Market Potential by Resource

Year	Total (kW)	BI-PV (kW)	LFG (kW)	Dairy & Food Waste (kW)	Incremental WWT (kW)
2003	5,263	685	4,344	167	67
2004	6,639	1,593	4,540	395	111
2005	7,859	2,442	4,733	541	143
2006	8,694	2,885	4,916	726	167
2007	9,960	3,765	5,090	919	186
2008	12,588	6,004	5,256	1,124	204
2009	16,108	9,118	5,413	1,356	221
2010	21,061	13,631	5,563	1,570	298
2011	24,663	16,831	5,704	1,777	351
2012	27,721	19,460	5,839	2,033	389

Figure 3-3: Expected Market Potential by Resource

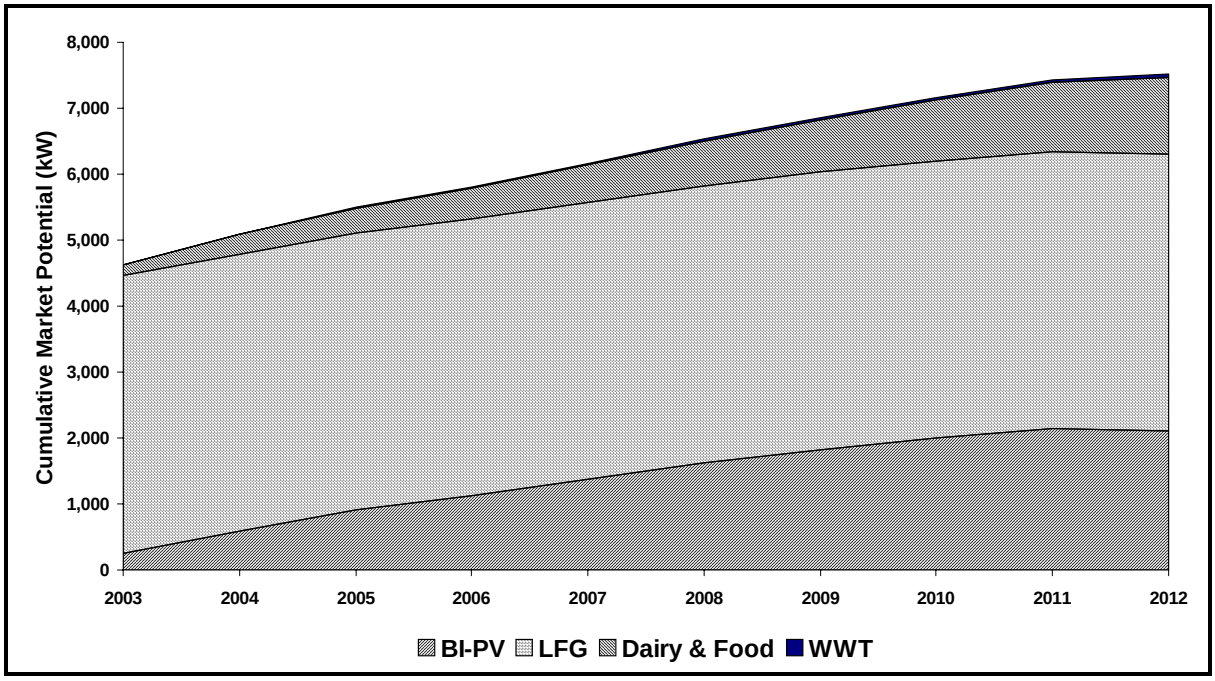


In the combined low market scenario, market potential reaches 7.5 MW, and the LFG resource dominates throughout the entire planning horizon. By 2012, BI-PV begins to make a major contribution to the total. The results are shown in Table 3-12 and Figure 3-4.

Table 3-12: Low Market Potential by Resource

Year	Total (kW)	BI-PV (kW)	LFG (kW)	Dairy & Food Waste (kW)	Incremental WWT (kW)
2003	4,630	258	4,200	167	4
2004	5,098	585	4,200	305	8
2005	5,501	906	4,200	383	12
2006	5,806	1,124	4,200	467	16
2007	6,161	1,368	4,200	573	20
2008	6,531	1,619	4,200	689	24
2009	6,855	1,830	4,200	797	27
2010	7,168	2,004	4,200	929	35
2011	7,427	2,135	4,200	1,050	42
2012	7,521	2,103	4,200	1,169	49

Figure 3-4: Low Market Potential by Resource

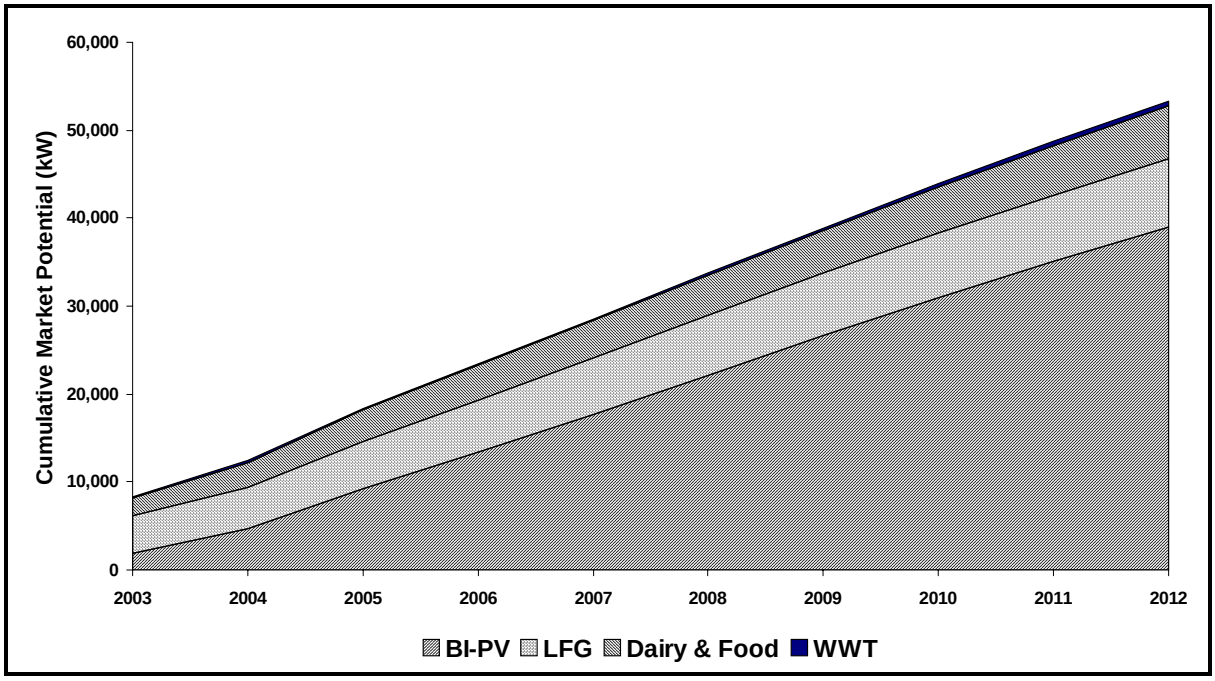


In the combined high scenario, market potential for the renewable resources within the mini-grid is approximately 8 MW in 2003 and increases to 53 MW by 2012. In the first year, the combined potential is dominated by the LFG. By the end of the planning horizon the BI-PV potential dominates the combined potential by a large margin. The results are shown in Table 3-13 and Figure 3-5.

Table 3-13: High Market Potential by Resource

Year	Total (kW)	BI-PV (kW)	LFG (kW)	Dairy & Food Waste (kW)	Incremental WWT (kW)
2003	8,362	1,851	4,344	2,017	150
2004	12,415	4,671	4,736	2,833	176
2005	18,348	9,293	5,285	3,580	189
2006	23,472	13,358	5,908	4,005	201
2007	28,545	17,674	6,407	4,252	213
2008	33,745	22,163	6,805	4,547	229
2009	38,852	26,604	7,124	4,879	245
2010	43,968	30,893	7,379	5,255	442
2011	48,711	35,024	7,584	5,627	476
2012	53,292	39,005	7,747	6,046	494

Figure 3-5: High Market Potential by Resource



Summary of Key Economic and Market Drivers

The key economic and market drivers for each of the four renewable resources are as follows:

- For BI-PV, the key economic driver is availability of financial support through utility ratepayer funded public purpose rebate/buydown programs and tax-related

government incentives.[2] In addition, consumer level of familiarity with the technology is a key market driver, as currently many consumers are unfamiliar with solar electric distributed generation technology, and may even confuse it with solar thermal technology.

- The potential for landfill bioreactors is heavily driven by the regulatory approval processes and requirements within the local mini-grid region.
- For dairy waste resources, the key economic driver is not so much the capital costs, but rather the environmental benefits accrued from the reduction in reactive organic gases and the reduction in nitrates leaching into the groundwater.
- The key driver for the food waste resource is the relative economics for the food processing companies in the area. Disposal of the food processing wastes is not the only option available to these firms, and some of the firms have already developed economic alternative uses for the substances within their process waste streams. The most viable option to take advantage of biogas production from these wastes may be to integrate food waste into the wastewater treatment AD systems that already exist.
- The potential for enhanced WWT processes to produce additional biogas to energy is driven by the willingness of IEUA, the WWT agency located within the mini-grid, to take advantage of new advancements in anaerobic digestion, energy recovery, and gas cleaning technologies that are being developed. The economics appear to be very favorable given the potential outcomes. The primary risk is in demonstrating the true performance and reliability of these technologies.

There is a very large technical and economic potential for biogas and non-residential BI-PV distributed generation within the Commerce Energy mini-grid. In fact, the total gross technical potential of 599 MW is actually slightly greater than the **entire peak electric load on the distribution system** within the mini-grid itself. In the expected case, this incremental renewable generation that will impact the electric grid is estimated to be less than 4% of the gross technical potential by 2012.

In order for more of this potential to be adopted within the mini-grid, many market barriers will need to be overcome. New ownership models may be necessary to help overcome some of the market entry barriers. Publicly supported incentives and educational programs can have an impact on market adoption if they are persistent and are perceived as reliable and part of a longer-term strategy. The development of environmental emissions credit markets has the potential to monetize the environmental benefits that can be accrued. These various regulatory driven credit markets would make an already economical renewable generation market even more competitive to third party project developers.

[2] Over $100 million dollars of ratepayer funded incentives are currently available for BI-PV systems statewide. Continued availability of such financial support depends on political, regulatory and other circumstances and therefore is uncertain.

3.4 Economic and Environmental Benefits of Mini-Grid Renewable Resources

Economic Benefits

The economic benefits of the renewable resources examined under this project are captured in the economic potential assessment and the T&D public benefits results.

The economic potential assessment involved cash flow modeling of technology prototypes developed to represent those that are likely to be implemented in the Chino Basin as well as those explored in other PIER Commerce Energy Projects under the broader PIER Commerce Energy research, development and demonstration program. The selected financial measure of performance used in this analysis was the internal rate of return (IRR). The IRR was computed for these prototypes under a number of financial conditions consistent with the three economic and market scenarios. These cash flow analyses results were subsequently fed into the economic hurdle rate model developed for this project to determine the relative portion of the technical potential that is considered economically viable.

The results of these assessments present a comprehensive picture of the prospects for biogas and BI-PV distributed generation within the defined mini-grid. The results for the expected scenario are summarized in Table 3-14.

Table 3-14: Expected Scenario Potential – Biogas and BI-PV Resources

Year	Gross Technical Potential	Net Technical Potential	Incremental Known Projects (kW)	Remaining Economic Potential (kW)
2003	598,842	598,771	4,200	195,426
2004	619,895	614,632	150	141,828
2005	639,962	633,472	0	72,634
2006	654,521	646,812	0	69,144
2007	665,732	657,188	0	119,977
2008	677,422	667,612	0	275,713
2009	688,401	675,963	0	385,754
2010	700,287	684,329	0	558,473
2011	710,544	689,632	0	437,444
2012	720,958	696,445	0	392,405

In this base scenario, the cumulative economic potential for all four of the identified Program renewable resources are 32.6% of the gross technical potential in 2003. This technical potential expected saturation rate grows to 54.4% by 2012.

The T&D benefits are discussed in more detail in Section 3.5 of this report.

Project specific economic benefits were examined in the prioritization of potential pilot projects as well. The ratio of the expected lifetime revenue over the expected project cost from the project owner's perspective was developed for each project. This benefit/cost ratio is defined as the present worth of the 15-year direct electric revenue stream (numerator of the ratio) discounted at 9% divided by a rough-order-of magnitude (ROM) cost for the project(s). The value of the electricity for the biogas projects was based on an average rate of$0.09/kWh applied to all the electricity produced. For the BI-PV projects, the value of electricity took into consideration the time value of electricity, which is typically greater at peak hours as opposed to off peak hours. Since BI-PV electric production typically occurs at peak hours, the value of electricity used to estimate the revenue stream for these projects varied between approximately $0.12/kWh and $0.17/kWh, depending on each site's electric rate. The ROM costs are the estimated capital costs for the projects. The expected lifetime revenue (numerator of the ratio) was discounted back to present value using a discount rate of 9 percent. A lifetime of 15 years was assumed. Results are shown in Table 3-15.

Table 3-15: Benefit / Cost Ratio for Prioritized Biogas and BI-PV Projects

Project	B/C Ratio
Biogas Projects	
3.1 Projects - Gas Cleaning (Dairy Operations)	N/A[1]
3.1 Projects - RESIDUALS MANAGEMENT	N/A[1]
3.1 Projects - GAS PRODUCTION ENHANCEMENT	4.75
3.1 Projects - Co-Digestion at RP-1	1.72
2.1 Project - Landfill Bioreactor	3.40
2.2 Projects - Ultrasound at Riverside	2.38
2.2 Projects - Gas Treatment (Sewage Treatment Plants)	N/A[1]

Table 3-15: Benefit / Cost Ratio for Prioritized Biogas and BI-PV Projects (Continued)

Project	B/C Ratio
BI-PV Projects	
3.3 Projects - Ontario School District facility	0.30
3.3 Projects - U.S. Navy Facility	0.31
3.3 Projects - CA Institute for Women	0.23
3.3 Projects - FEDCO facility	0.17
3.3 Projects - IEUA / IKEA facility	0.21
3.3 Projects - Civil Air Patrol facility	0.29
3.3 Projects - Ranch View Elem. School facility	0.30
3.3 Projects - San Bernardino Co. Maintenance facility	0.29
3.3 Projects - Riverside Comm. College facility	0.18
3.3 Projects - YMCA facility	0.29
Notes: 1. N/A – Benefit/Cost ratio not analyzed.	

Environmental Benefits

There are several environmentally related non-energy benefits associated with dairy waste biogas to energy facilities. The first major benefit is groundwater decontamination. This is very significant to the Chino basin mini-grid area due to the nitrates (salts) that leach into the groundwater as a result of current manure management practices. It is expected that as improvements in manure management are made to facilitate the collection and transportation of dairy waste to centralized anaerobic digester (CAD) facilities, fewer salts and related contaminates will be required to be removed from the groundwater, thereby reducing the future cost of groundwater cleanup efforts in the basin.

The second environmentally related non-energy benefit associated with dairy waste biogas, and to a lesser degree for landfill biogas and wastewater treatment biogas, is the reduction in reactive organic and greenhouse gas emissions, namely ammonia, methane and nitrous oxides. It is conceivable that markets for methane emission reduction credits will be created by regulatory actions in the future. Niche markets may well exist for this within 10 years. The development of an ammonia credits market is much more uncertain. The drawbacks of ammonia emissions are more limited to odor problems and to a lesser degree the impact on local vegetation as a result of re-deposition. More importantly, ammonia is believed to be a precursor for PM_{10} and may in the near future be valued far greater than GHG credits. However, it is not clear that a market for ammonia credits is as likely to develop as for methane credits.

A key valuation aspect from the economic potential perspective is whether the benefits are accrued by the owner of the CAD facilities. In the case of groundwater contamination, owners of CAD facilities would not necessarily be expected to be responsible for ground water cleanup. One of the prototypes used in the market assessment includes a public agency to own and operate CAD facilities. A public agency within the mini-grid (IEUA) has been contracted to initiate a pilot plant to test groundwater contamination cleanup in the mini-grid area -- that is also testing a dairy CAD pilot facility. In this case it is certainly conceivable that the public agency will realize future groundwater cleanup cost savings from their dairy CAD operations. The real question is: what is the estimated magnitude of this financial benefit?

To incorporate the impact of a future GHG credits market into the market potential assessment, the issues of GHG quantification and credit valuation need to be addressed. The valuation of the GHGs has been done on a carbon dioxide equivalent (CO_2E) basis. Methane is assumed to have a CO_2E of 21:1. In other words, every ton of methane is assumed to be equivalent to 21 tons of CO_2. In the case of nitrous oxide (N_2O), the assumed CO_2E conversion is 310:1. The value of the GHG credits was computed on an animal unit (AU) basis. The final value for methane used in the market assessment was $1.06 per AU per year and the value of N_2O was $0.91 per AU per year for a total GHG credit of $1.97 per AU per year.

The avoided cost of salt contamination removal was developed based solely on the variable O&M costs for a reverse osmosis system. The avoided cost value derived was $688 per AU. The avoided cost impact of the CAD on ground water contamination was assumed to take five years from the time the CAD began operation. The derivation of a value for this environmental benefit will further be addressed in the early process analysis and selection tasks of Project 3.1 dairy waste to energy pilot of the PIER Commerce Energy Program.

Some portion of consumers ascribe value to the environmental and other distinctive attributes corresponding to PV-based electrical energy production, and are willing to pay for some quantity of these attributes. This willingness to provide economic contribution can be viewed in at least two different lights. First, a consumer may choose to install a PV system on his or her own building. For a consumer making this decision, if the total levelized cost of PV-based electrical energy production and power output exceeds the cost of electrical energy and power from conventional sources then the difference represents the incremental willingness to pay more for PV. Second, a consumer may choose to purchase the non-electric attributes corresponding to the production of a PV system owned by someone else. In this case the non-electric attributes may be represented by the value of the “green tags”, or Renewable Energy Certificates (RECs).

The total incremental value ascribed by society to non-electric attributes of PV-based electrical energy production and power output could be accounted for in the market potential assessment by using the "own building" model, the "green tags" model, or both. The "green tags" model was used the market potential assessment of BI-PV. Although far from mature, markets for green tags do exist today. A consumer with a credit card and an Internet connection can purchase green tags in a matter of minutes. While markets for green tags exist, they are in their infancy. It may not yet be possible to purchase green tags corresponding solely to PV system operational attributes. To date, because of their market volume and relative cost of electric generation, most green tags transactions have involved wind power. However in the future, as RPS standards are implemented and generation volumes increase, more robust markets for PV-based green tags are likely to develop.

It is not possible to know precisely what PV-based green tags prices will be in the future. In the case of one program involving 80 kW of PV, owners of some small PV systems in Oregon and Washington are selling the non-electric attributes corresponding to operation of their PV systems for 10 cents/kWh under 5-year contracts. Conversations with others familiar with green tags markets and renewable energy project development suggest that larger-scale markets might price PV-based green tags somewhere in the neighborhood of 4 to 6 cents/kWh. For this market potential assessment a range of green tags values was defined. For the *expected-potential* scenario a PV green tag value of 2 cents/kWh was assumed. Conversations with others familiar with green tag markets and renewable energy project development suggest that larger-scale markets might price biogas-based green tags somewhere in the neighborhood of 0.5 cent/kWh. Since better market information is not currently available, the biogas green tag value has been assumed to be fixed over time.

3.5 Estimation of Future Mini-Grid Renewable Resource T&D Public Benefits

The renewable penetration scenarios for 2007 and 2012 are all less than 10% of the Chino mini-grid peak loads. Impacts on the T&D system were evaluated for three scenarios (an expected case, a high case and a low case) and benefits were found for five areas, each discussed briefly below.

- ***Distribution Facility Deferral Benefits***. BI-PV and biogas projects can be strategically located throughout the heavily loaded distribution system to reduce peak feeder and distribution substation loads, deferring facility additions and resulting in a distribution facility deferral economic benefit. This potential economic benefit applies primarily to heavily loaded distribution facilities. If BI-PV and biogas projects are installed on lightly loaded distribution feeders, there will not be an economic benefit, even if the (lightly loaded) distribution system peak loads are reduced. The potential benefits are summarized in Table 3-16.

Table 3-16: Potential Distribution Facility Deferral Benefits

Year	Distribution Facility Deferral Benefit in Terms of PWRR* ($1000)					
	Expected Case		High Case		Low Case	
	Full Output	90% Output	Full Output	90% Output	Full Output	90% Output
2007	0	0	1,018	0	0	0
2012	2,027	1,709	4,357	3,835	0	0

*Present worth of revenue requirements

- ***Distribution System Loss Reduction Benefits.*** Generally, annual distribution system resistive (I^2R) losses will tend to reduce as distributed generation increases up to a point when the distributed generation output equals the distribution loads. After this, distribution losses may tend to increase as the distributed generation increases. The magnitude of the values of the hourly losses in Table 3-17 indicate that potential distribution system loss benefits will be small for the renewable penetration scenarios considered in this study.

Table 3-17: Potential Hourly Mini-Grid Distribution Loss Value

Year/Load	Wholesale Rate	Hourly Loss Value ($)					
		Expected Case		High Case		Low Case	
	$/MWh	Full Output	90% Output	Full Output	90% Output	Full Output	90% Output
2007 Peak	34.60	14	11	43	34	8	7
2007 Light	34.60	6	4	16	13	3	3
2012 Peak	49.70	69	56	126	102	18	14
2012 Light	49.70	26	21	46	37	7	6

- ***Distribution Voltage and Power Factor Correction Benefits.*** Installing distributed BI-PV and biogas projects can improve distribution system voltage regulation by supplying real power (kW) during peak loading and by improving voltage regulation or provide power factor correction. In this study, the renewable generation was operated at unity power factor. Potential voltage spread problems were identified with the distributed generation operating in this manner. However, since these generators are expected to supply or absorb vars as scheduled to maintain proper voltage regulation in the distribution system when the generation is operating, there is no voltage spread penalty. These distributed generators also would not be allowed to operate in a voltage regulation mode, so there is no voltage regulation benefit either.
- ***Transmission and Subtransmission Facility Deferral Benefits.*** Transmission and subtransmission facility deferral benefits are difficult to identify and quantify for the small, distributed generation penetration scenarios considered in this study, due to the order of magnitude difference between transmission and subtransmission facility ratings and distributed generation size (up to 54 MW). However, general transmission system capital investment requirements as a function of load increase in the vicinity of the mini-grid may be available from

transmission studies to assign transmission system deferral benefits to distributed resources or other demand side resources.

- ***Transmission and Subtransmission Loss Reduction Benefits.*** Transmission and subtransmission loss benefits are difficult to identify and quantify for the small, distributed generation penetration scenarios considered in this study, due to the order of magnitude difference between transmission and subtransmission losses and transmission loss impacts of the distributed generation size (up to 54 MW). As an alternative, general transmission system loss impacts as a function of load or energy may also be available from transmission studies to assign transmission system loss benefits to distributed resources or other demand side resources. Potential transmission and subtransmission system loss reductions for the expected, high and low mini-grid renewable penetration scenarios during 2007 and 2012 peak load conditions are shown in Table 3-18.

Table 3-18: Potential Hourly Transmission and Subtransmission Loss Value

Year	Wholesale Rate	Hourly Loss Value ($)					
		Expected		High		Low	
	$/MWh	Full Output	90% Output	Full Output	90% Output	Full Output	90% Output
2007 Peak	34.60	9	7	22	18	6	5
2012 Peak	49.70	32	26	59	48	9	8

Key Findings

Key findings and observations resulting from the mini-grid power flow study are as follows:

- Since the renewable penetration scenarios evaluated in this study are less than 10% of the mini-grid loads, the resulting mini-grid loss reductions are relatively small.
- No voltage regulation or power factor correction benefits or penalties were identified in this study.
- Distribution system voltage control problems may occur if large MW-scale distributed generators are added near the end of distribution feeders in the mini-grid.
- Flicker is not expected to be a problem for the expected, high and low renewable penetration scenarios assumed in this study.
- Distribution relaying schemes may need to be changed to properly accommodate reverse power flows resulting from large penetrations of distributed generation.
- BI-PV output and the biogas generation output will correlate nicely with the mini-grid annual early afternoon peak loads. Several new substation transformers and feeder additions will be required over the study period, and future mini-grid distribution facility additions can be deferred.

- No transmission and subtransmission facility deferral benefits were identified in this study.
- Potential transmission and subtransmission system loss reduction benefits calculated during peak loadings indicate that potential annual transmission system loss benefits will be smaller than the distribution loss benefits for the renewable penetration scenarios studied.

3.6 Prioritized Renewable Generation Candidate Facilities

The list of potential projects includes all of those evaluated for both the biogas and PV sections of the prioritization report.[3] They are listed in Table 3-19.

Table 3-19: Projects Evaluated in Prioritization Model

Biogas Projects
3.1 Projects – Gas Cleaning (Dairy Operations)
3.1 Projects – Residuals Management
3.1 Projects – Gas Production Enhancement
3.1 Projects – Co-Digestion at RP-1
2.1 Project – Landfill Bioreactor
2.2 Projects – Ultrasound at Riverside
2.2 Projects – Gas Treatment (Sewage Treatment Plants)
BI-PV Projects
3.3 Projects – Ontario School District
3.3 Projects – U.S. Navy Facility
3.3 Projects – CA Institute for Women
3.3 Projects – FEDCO
3.3 Projects – IEUA/IKEA
3.3 Projects – Civil Air Patrol
3.3 Projects – Ranch View Elementary School
3.3 Projects – San Bernardino County Maintenance
3.3 Projects – Riverside Community College
3.3 Projects – YMCA

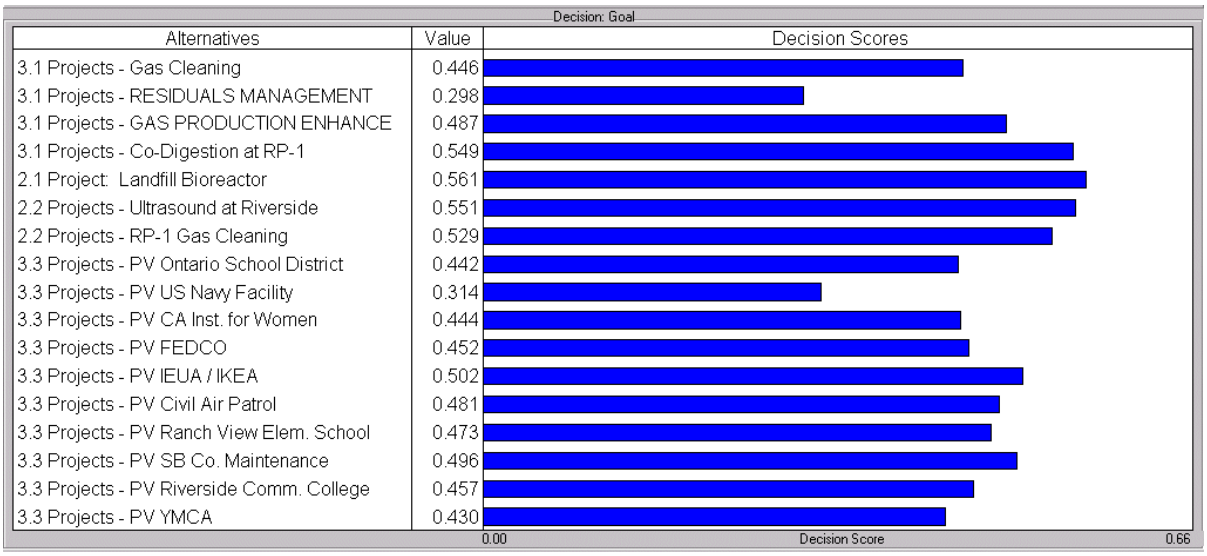
Project Scores

Each potential project was scored on the lowest-level attributes listed in Section 2 of this report. These scores were entered into the objectives hierarchy. The scoring software generated absolute scores between 0 and 1 for each alternative project, allowing a ranking of projects. Results from the model are shown in Figure 3-6. All scores are normalized to a 0.0 to 1.0 scale, with 1.0 being an "ideal" project, i.e. it would have scored highest on all attribute scales. As shown, of all the identified projects, the proposed landfill bioreactor

[3] Project Prioritization Assessment - Task 1.1.10 Final Report, April 2004.

project at the Mid-Valley landfill site scored highest, due primarily to its size and contribution to the Commerce Energy Business Plan goals. It is followed by the application of ultrasound for increased biogas production at Riverside.

Figure 3-6: Project Prioritization Scoring Results



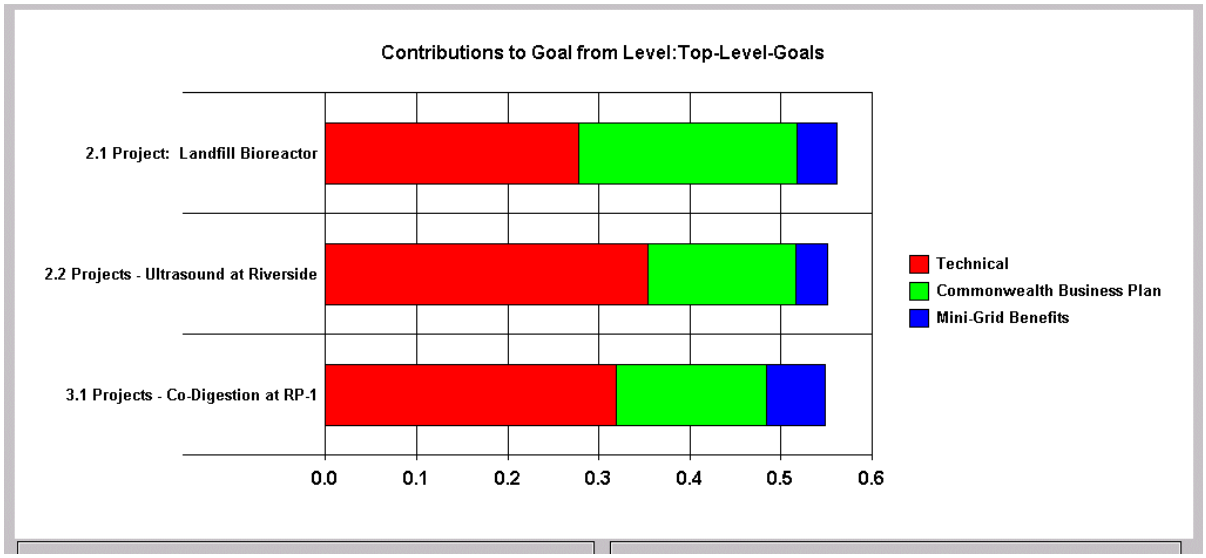
Project Groupings (Tiers) by Ranked Score

Based on the scoring results above, the projects have been grouped into a Tier 1, Tier 2 and Tier 3 for both the Biogas and the BI-PV opportunities. Tier 1 projects are those that scored highest (generally above 0.5 on scale of 0.0 to 1.0) and therefore are the ones that best meet the objectives of the Commerce Energy Business Plan and the other objectives of the PIER Renewables Program. In order to better focus efforts, these projects will be implemented first. Tier 2 projects typically have scores above 0.4, and could proceed, but only if they do not divert the Team's efforts from effectively implementing projects within Tier 1. Tier 3 projects scored below 0.4, and while technically worthwhile, do not meet the Commerce Energy Business Plan or other key objectives of the program sufficiently for them to proceed, given the other identified project opportunities.

Tier 1 Biogas Projects

Figure 3-7 shows the three Tier 1 biogas projects, and contributions to scores for each project from the top-level criteria (Commerce Energy Business Plan, mini-grid benefits, and technical attributes). All of these projects scored above 0.5 on the absolute overall scoring scale of 0.0 to 1.0.

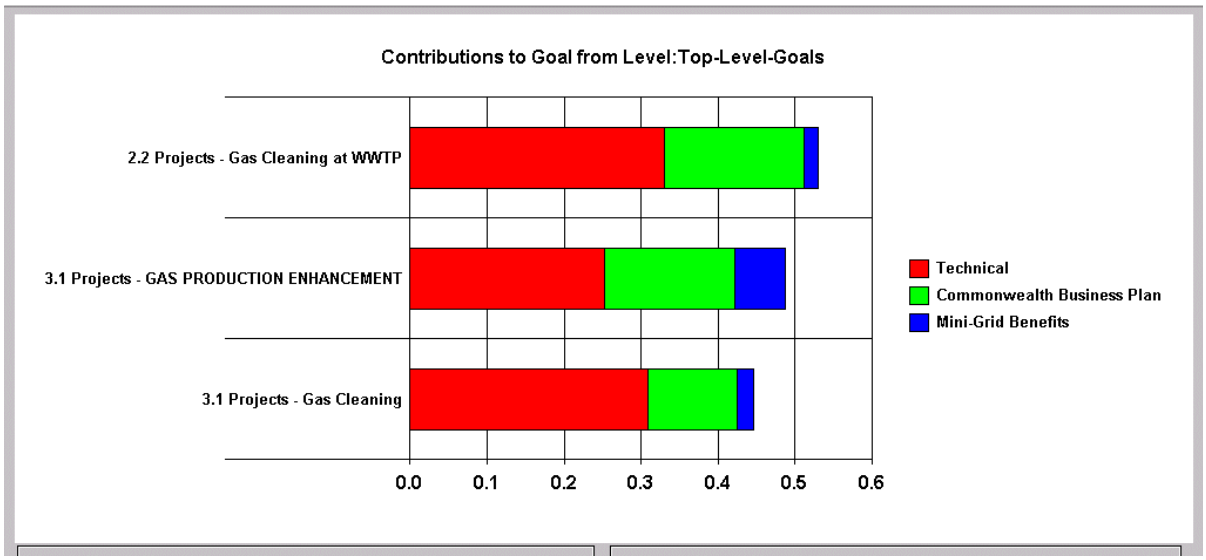
Figure 3-7: Tier 1 Biogas Projects



Tier 2 Biogas Projects

Figure 3-8 shows the three Tier 2 biogas projects, and contributions to scores for each project from the top-level criteria (Commerce Energy business plan, mini-grid benefits, and technical attributes). Two of these projects scored between 0.4 and 0.5 on the absolute overall scoring scale of 0.0 to 1.0. The third, which is the 2.2 project for gas cleaning and treatment at wastewater treatment plants, scored above 0.5, and would be the first project to move to Tier 1 or to implement from the Tier 2 group.

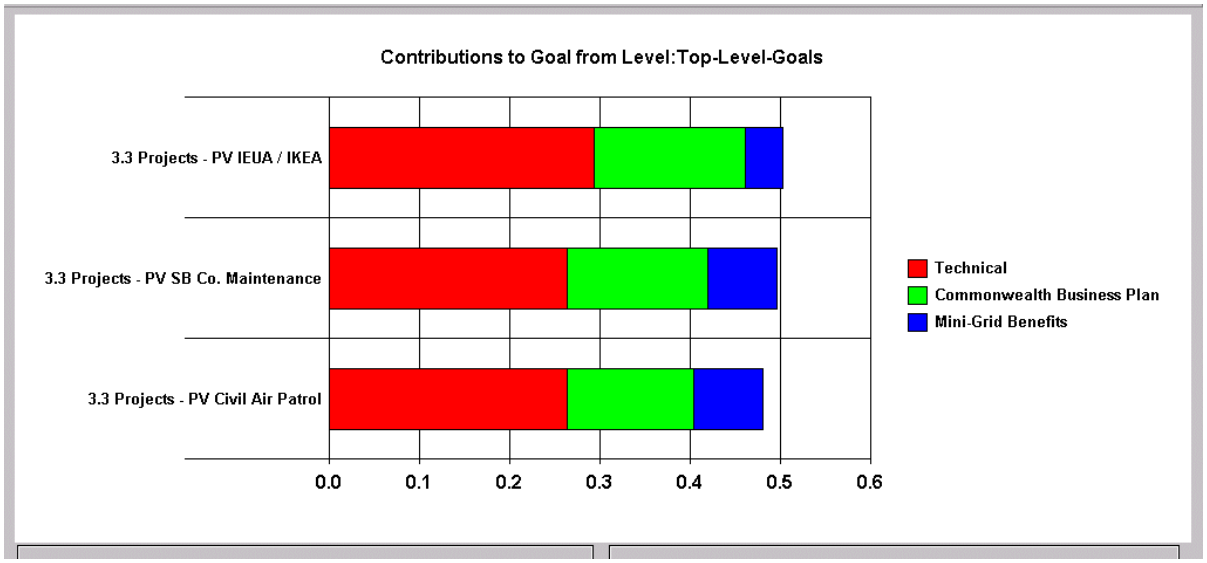
Figure 3-8: Tier 2 Biogas Projects



Tier 1 BI-PV Projects

Figure 3-9 shows the three Tier 1 BI-PV projects, and the contributions to scores for each project from the top-level criteria (Commerce Energy business plan, mini-grid benefits, and technical attributes). The total scores for these three projects were in a close range 0.481 to 0.502 on the absolute overall scoring scale of 0.0 to 1.0.

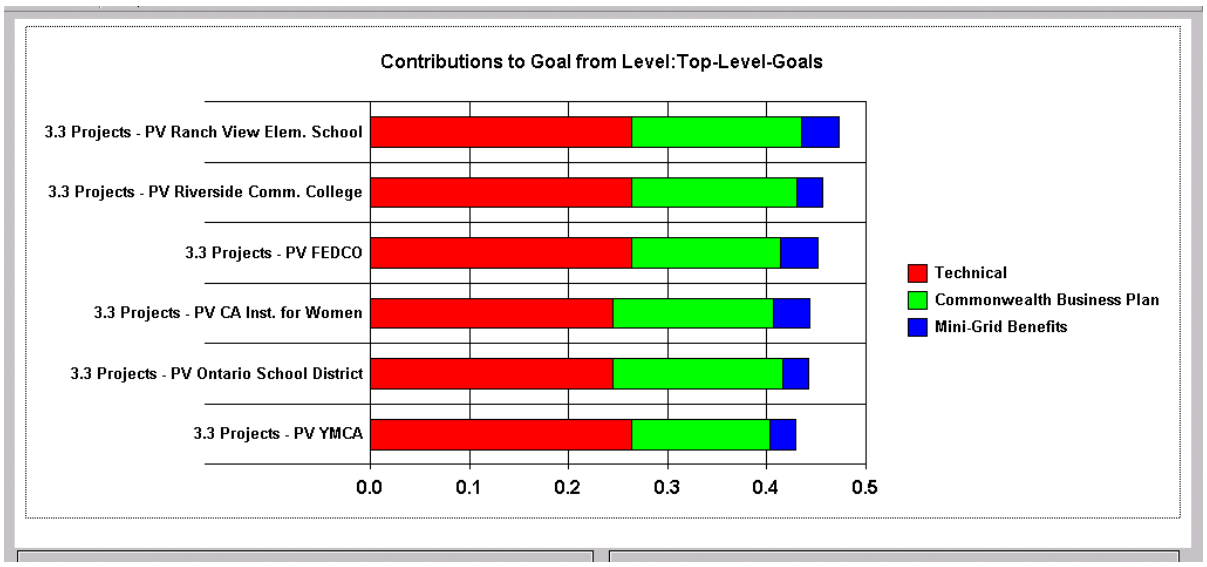
Figure 3-9: Tier 1 BI-PV Projects



Tier 2 BI-PV Projects

Figure 3-10 shows the six Tier 2 BI-PV projects, and contributions to scores for each project from the top-level criteria (Commerce Energy business plan, mini-grid benefits, and technical attributes). All of these projects scored above 0.4 on the absolute overall scoring scale of 0.0 to 1.0.

Figure 3-10: Tier 2 BI-PV Projects



Key Findings

A range of potential projects to increase affordability of renewable energy within the mini-grid and California has been identified in this first phase of the PIER program. This analysis has taken different program objectives as expressed by Commerce Energy Energy and Energy Commission PIER program management and put those objectives into a weighted hierarchy, then scored each of the projects along all of the objectives. The results show that the top five projects for consideration include:

- [2.1Project]: Landfill Bioreactor at the Mid-Valley Landfill site
- [2.2 Project]: Ultrasound application for biogas enhancement at Riverside County wastewater treatment plant
- [3.1 Project]: Implementation of Co-Digestion of animal waste with food waste at the IEUA RP-1 facility
- [2.2 Project]: Gas cleaning for improved performance of generation equipment at IEUA RP-1 facility
- [3.3 Project]: PV project at IEUA (prior IKEA) composting facility.

Two more PV projects score closely to those in this list, and are also worthy of further consideration and analysis:

- San Bernardino County Maintenance facility and
- Civil Air Patrol facility.

For both the biogas and BI-PV projects, the prioritization list falls into "tiers", where Tier 1 are projects worthy of implementation, Tier 2 are projects that may be implemented after Tier 1 project resource requirements are met, and Tier 3 projects are not sufficiently close to the stated goals of the program to be implemented.

3.7 Summary of Project and Program M&E Plans

A comprehensive measurement and evaluation (M&E) plan was developed to evaluate the effectiveness of the individual projects as well as the Program as a whole, This plan will be used to evaluate each of the specific projects and each project's contribution to the overall Commerce Energy Program-level goals and objectives. This plan defines, for the Program-level and the distinct project objectives, specific performance metrics, data collection plans, analysis techniques, and the M&E implementation schedule.

Three measurement and evaluation (M&E) activities are planned for each implemented project. These include: 1) Pilot Performance, 2) Technology Transfer and 3) Market Impact. Each project-level M&E activity is discussed briefly below.

Pilot Performance M&E

The test plans and pilot performance measurement and evaluation protocols will be reviewed as follows:

- System evaluation test plans will be compared with the actual evaluation methods used, and discrepancies or inconsistencies between the two will be identified.
- Telephone interviews will be conducted with the TAC and other team members to solicit their opinions on the literature review of other systems and how they feel these systems compared to others studied.
- System installers not selected for mini-grid test sites will be interviewed to provide feedback on the installations and results of the pilot program in terms of its demonstration value for similar installations.
- An evaluation of the test facility will be conducted to determine the effectiveness of serving the overall program objectives.
- The working relationship among TAC and RPAC members will be assessed. In particular, lessons learned by TAC and RPAC members in connection with the BI-PV pilot program will be documented.

M&E of Technology Transfer Activities

The Project Test Plans will be reviewed to evaluate the effectiveness of this BI-PV project in usefully transferring the lessons learned to other Commerce Energy team members, and to

other participants in the PV supply channel and development community. The emphasis of this part of the evaluation will be on how well the pilot program has done in lowering the economic and institutional barriers to acceptance. The assessment will involve the following:

- Interviewing federal agencies such as NREL, DOE, National Labs, etc.;
- Reviewing and summarizing trade publication articles and workshop or conference presentations;
- Interviewing team members and other BI-PV installers to determine how well the lessons learn from the project have been transferred and the level of awareness about the project with the industry and the degree to which institutional barriers such as contracting issues, building and inspection issues, and economic feasibility issues have been addressed by the project;
- Assessing website activity;
- Reviewing the appropriateness and applicability of the Project's plans with respect to the ability of the project to provide recommendations for a National Systems Rating Performance Standard.

M&E of Market Impacts

Likely market impacts will be assessed by examining whether the targeted demonstrations were successful. These include:

- Demonstration of the technical and economic feasibility;
- Demonstration of equipment and service provider selection criteria; and
- Demonstration of a performance evaluation rating system.

The impacts will be judged on the resulting cost-effectiveness of the demonstrations as well as their effectiveness in mitigating non-cost barriers. This assessment will be qualitative in nature as there are no clear quantitative measures of success. A judgmental assessment of the demonstrations will be requested during interviews with RPAC, TAC, Energy Commission staff, and other industry stakeholders. Specific attention will be given to the impacts on the local mini-grid as well as the statewide market impacts.

Review of BI-PV Component Selection (Project 3.2 Only)

The review of election criteria will include performing the following activities:

- Conduct a literature search to identify and retrieve the results of previous testing of the PV components selected for the BI-PV systems. The search will include an online search as well as contacts with the equipment manufacturers representatives as needed.

- Conduct telephone interviews with all TAC members and appropriate Energy Commission staff to review the selection criteria and the choice of components and systems. These discussions will be open-ended and intended to allow the interviewees a chance to comment on the entire system configurations, including any relevant locational considerations.
- Based on the above input, conduct telephone interviews with project team lead to provide feedback and to obtain clarification about issues raised in the interviews and literature search.
- Assess the above input in the context of a careful review of the programmatic purposes to determine whether the BI-PV Components and Systems selection criteria are best suited to the overall program. The applicability of the systems to the Energy Commission Emerging Buydown Incentive Program and the CPUC's Self-Generation Incentives program will also be evaluated.

Program M&E Plan

The M&E activity for the overall Commerce Energy Program focuses on the success of the following Program objectives:

- Develop and implement an approach for tailoring resource development to the specific needs and resources of local areas, or mini-grids,
- Improve affordability & diversity of local renewable resources through recognition or internalization of external public benefits (electric grid operations cost reductions, air emissions, groundwater impacts, etc.),
- Develop an RD&D Program that can be replicated elsewhere in CA, and
- Leverage public PIER RD&D funding with private investment and related private benefits.

To a lesser extent, the objectives specific to the individual projects conducted under the Program need to be evaluated as a whole. These individual projects have their own M&E plans and will be assessed accordingly, but to the extent that they are part of the overall Program their success must be viewed from an overall perspective.

The assessment of how well the Program has achieved its objectives will be accomplished through a) interviews with RPAC members, b) interviews with Commerce Energy Energy's project team members, and c) review of the individual project M&E reports.

3.8 Summary of Outcomes

To summarize, the Commerce Energy team conducted an inventory of the biogas and non-residential BI-PV resources within the Chino Basin study area. This was refined using information on Southern California Edison's T&D system to establish the Chino mini-grid

area. The current combined technical potential in the mini-grid area was estimated to be approximately 600 MW. A market potential analysis resulted in an estimate of the combined current market potential for the mini-grid in the range of 4.6 MW to 8.4 MW with an expected value of 5.3 MW. The expected value was estimated to grow to nearly 28 MW by 2012. In the early years the market potential is dominated by LFG. However, by 2012 the market potential is dominated by the non-residential BI-PV potential. In order for more of the technical potential to be realized within the mini-grid, many market barriers will need to be overcome. New ownership models, greater publicly funded incentives and educational programs, and the development of environmental emissions credit markets can have an effect on market adoption.

Power flow modeling of the mini-grid's electrical T&D system showed that there were significant equipment upgrade deferral benefits to be had as a result of the expected market potential for the renewable resources. These benefits increased significantly when the high end of the market potential was modeled. Other T&D system benefits such as voltage and VAR support were found to be very small.

The economic and environmental benefits associated with the renewable generation potential have been found to be specific to the mini-grid. The Chino basin has considerable ground water contamination and air pollution directly resulting from dairy cattle waste. Full development of the renewable distributed generation resources has the potential to improve environmental management within the mini-grid. The development of renewable energy credit markets would help stimulate the development of the mini-grid.

Because the technical potential can be so large within the mini-grid area, as demonstrated in the Chino mini-grid, some means of prioritizing the finite available public funds will be necessary so as to optimize the public benefits. The demonstration project prioritization phase of the Commerce Energy program has created a mechanism that can be replicated and provide this needed prioritization of public funds. By identifying all the relevant criteria and providing each with a numeric weighting factor, all future renewable generation projects within a mini-grid can be scored and prioritized to optimize their public benefit.

4

Conclusions and Recommendations

As stated in the Commerce Energy Biogas/PV Mini-Grid Renewable Resource Program work plan, the Project 1.1 (Program Planning and Analysis) overall goal is to develop an approach for tailoring resource development to the specific needs and resources of load areas or mini-grids with an emphasis on assessing and targeting renewable electricity development within the identified mini-grid that will help to improve the affordability of these renewable resource applications. This section of the Program Planning and Analysis Report presents the conclusions and the recommendations for implementation of the Commerce Energy Biogas/PV RD&D Program

4.1 Project 1.1 Conclusions

The Planning and Analysis Project examined the sources and potential applications of biogas and photovoltaic electric generation within the Chino basin in Southern California, and regional growth trends considering the impacts on the distribution system to arrive at an initial mini-grid study area. This initial study area was then refined based on the results of several tasks that focused on the assessment of the specific renewable resources and the establishment of an electric T&D system model within the Chino basin. The technical and market potential for the mini-grid were developed and their impact on the local electric T&D system was modeled over time. The conclusions reached from these analyses center around four specific areas:

- Near-term biogas and BI-PV Market Potential (MW capacity over a 10 year period)
- Distribution system Impacts of fully realized market potential within the Mini-Grid (Power Flow Analysis)
- Local Economic and Environmental Impacts, and
- Development of a methodology to prioritize biogas and BI-PV project opportunities with respect to Commerce Energy's renewables business plan objectives, the electric distribution system impacts and the Program's RD&D objectives.

The conclusions are discussed here in greater detail.

Market Potential

There is a very large technical and economic potential for biogas and non-residential BI-PV distributed generation within the Commerce Energy defined mini-grid. In fact, the total gross technical potential of 599 MW is actually slightly greater than the entire peak electric load on the distribution system within the mini-grid itself. At present, the expected market adoption of this potential is not estimated to be very large, in large part due to the fact that nearly 5MW of distributed generation at WWT facilities currently exists that will simply switch its fuel supply over time as biogas resources are developed. In the expected case, this incremental renewable generation that will impact the electric grid is estimated to be less than 4% of the gross technical potential by 2012. In the *aggressive green* or high case scenario, this estimate increases to 7.4% of gross technical potential.

Market adoption of the economic potential for alternative generation has traditionally not been very significant. In order for more of this potential to be adopted within the mini-grid, many market barriers will need to be overcome. Some of these barriers are typical of any relatively new and/or uncommon technologies. Research, development and demonstration projects as well as technology transfer initiatives may help to improve penetration rates. Other barriers are associated with the fact that non-residential establishments, such as the dairies in the basin, are not primarily concerned with their electric costs (or on-site generation) to remain in business. Even if it is economical, it is often considered a distraction from their primary business operations. New ownership models may be necessary to help overcome this market entry barrier.

The key economic and market drivers for each of the four renewable resources differ. For BI-PV, the key economic driver is availability of financial support through utility ratepayer funded public purpose rebate/Buydown programs and tax-related government incentives. Currently in California, these programs play an essential role in reducing costs by an amount necessary to stimulate the markets for this technology on a large scale. Continued availability of financial support depends on political, regulatory and other circumstances and therefore is uncertain. Consumer level of familiarity with the technology is a key market driver for BI-PV. Currently many consumers are unfamiliar with solar electric distributed generation technology, and may even confuse it with solar thermal technology. The speed with which familiarity and knowledge of the technology and systems increases will be an important determining factor governing future BI-PV deployment.

The potential for landfill bioreactors is heavily driven by the regulatory approval processes and requirements within the local mini-grid region. The current permitting requirements may prove to be prohibitive and are the single most important factor in the adoption of this renewable energy resource here and in other areas of California.

For the dairy waste resources, the key economic driver is not so much the capital costs, but rather the environmental benefits accrued from the reduction in reactive organic gases and the reduction in nitrates leaching into the groundwater. These environmental factors proved to have the potential for substantial economic benefits. These environmental benefits have the potential to be very large depending on how future environmental credit markets evolve. It is just a question of whether the critical mass of dairies will remain in business long enough for these waste management and energy recovery project benefits to be realized.

The key driver for the food waste resource is the relative economics for the food processing companies in the area. Disposal of the food processing wastes is not the only option available to these firms. Some of the firms have already developed economic alternative uses for the substances within their process waste streams. The most viable option to take advantage of biogas production from these wastes may be to integrate food waste into the wastewater treatment AD systems that already exist.

The potential for enhanced WWT processes to produce additional biogas to energy is driven by the willingness of IEUA, the WWT agency located within the mini-grid, to take advantage of new advancements in anaerobic digestion, energy recovery, and gas cleaning technologies that are being developed. The economics appear to be very favorable given the potential outcomes. The primary risk is in demonstrating the true performance and reliability of these technologies.

Power Flow Analysis

The results of this power flow study indicate that there are no “show stoppers” for the expected, high and low biogas and BI-PV generation penetration scenarios studied in this project. Key conclusions and observations resulting from this power flow study are as follows:

- Since the renewable penetration scenarios evaluated in this study are less than 10% of the mini-grid loads, the resulting mini-grid loss reductions are relatively small. Potential distribution system loss reduction benefits during peak and light loadings were calculated assuming expected wholesale electricity rates for 2007 and 2012. These calculations indicate that potential annual distribution system loss benefits will be small for the renewable penetration scenarios studied.
- No voltage regulation or power factor correction benefits or penalties were identified in this study.
- Potential voltage regulation problems were identified when a large several MW distributed generator was operated at the end of Feeder D6 in this study. Thus, distribution system voltage control problems may occur if large MW-scale distributed generators are added near the end of distribution feeders in the mini-

grid. This potential voltage regulation problem is location-specific and may limit DG penetration on some utility feeders.

- Flicker is not expected to be a problem for the expected, high and low renewable penetration scenarios assumed in this study.
- Several instances of reverse power flow in feeders were observed in this study. The reverse power flows were linked with the voltage regulation problems observed for the renewable penetration scenarios studied in this project. Voltage regulators and LTC transformers are not used in the mini-grid, so voltage regulator or LTC controls do not have to be modified to accommodate reverse power flows. However, distribution relaying schemes may need to be changed to properly accommodate reverse power flows resulting from large penetrations of distributed generation.
- Significant potential distribution facility deferral benefits were identified in this study, especially for 2012 expected and high renewable penetration scenarios. The results of this study indicate that the BI-PV output and the biogas generation output will correlate nicely with the mini-grid annual early afternoon peak loads, and that several new substation transformers and feeder additions will be required over the study period. If future operating experience and studies with BI-PV and biogas generation convince SCE that the generation can be counted on during the peak periods, future mini-grid distribution facility additions can be deferred.
- Transmission and subtransmission facility deferral benefits are difficult to identify and quantify for the small, distributed generation penetration scenarios considered in this study, due to the order of magnitude difference between transmission and subtransmission facility ratings and distributed generation size (up to 54 MW). No transmission and subtransmission facility deferral benefits were identified in this study.
- Transmission and subtransmission loss benefits are also difficult to identify and quantify for the small, distributed generation penetration scenarios considered in this study, due to the order of magnitude difference between transmission and subtransmission losses and transmission loss impacts of the distributed generation size (up to 54 MW). Potential transmission and subtransmission system loss reduction benefits during peak loadings were calculated assuming expected wholesale electricity rates for 2007 and 2012. These calculations indicate that potential annual transmission system loss benefits will be smaller than the distribution loss benefits for the renewable penetration scenarios studied.

Economic and Environmental Benefits

Economic Benefits

The economic benefits of the renewable resources examined in this project are captured by the economic potential assessment and the T&D power flow analysis that were performed for this project. The economic potential was driven by the internal rate of return associated with the development of renewable distributed generation (DG) projects. Those projects that

exceed the necessary hurdle rate for developers contribute to the potential. The presence of tax benefits, publicly financed incentives, and future green tag markets contribute greatly to the ability of these renewable DG projects to be economically viable.

The power flow analysis captured the economic benefits to the local T&D system. These economic benefits return to the public in the form of avoided rate increases to cover need system upgrades. The biogas DG and non-residential BI-PV resources in combination can provide a generation profile that nearly follows the load profile associated with the mini-gird electrical system. At the levels of market potential estimated for the mini-grid over the next 10 years, the capital costs associated with new substation transformers could be deferred. However, other system reliability benefits, such as voltage support, cannot be realized at the expected levels of market potential. Renewable DG market barriers will need to be removed before the necessary levels of market penetration can provide system reliability benefits.

Environmental Benefits

There are several environmentally related non-energy benefits associated with the biogas DG potential within the mini-grid. Two of the most significant are the reduction in ground water contamination and the reduction in air pollution. Ground water contamination due to nitrates (salt) emanating from dairy livestock can be significantly reduced in the future with the development of centralized dairy waste to energy projects. These same DG projects can also greatly reduce the emissions of reactive organic and greenhouse gas. It is conceivable that markets for emission reduction credits will be created by regulatory action and further stimulates the development of biogas DG projects.

Similarly, BI-PV may be enhanced by the development of green tags. Green tags can capture the value society ascribes to the environmental benefits of PV-based electrical energy production. In the future, as Renewable Portfolio Standards are implemented and generation volumes increase, more robust markets for PV-based green tags are likely to develop.

Methodology for Prioritization of Biogas and BI-PV Project Opportunities

The objectives of the prioritization approach were to tailor resource development by synchronize the operating features of a mix of renewable resources with the diurnal patterns of demand and the features of the local electric grid that should make future development efforts more cost effective and lead to more affordable energy.

Since the establishment of the original objectives, the Commerce Energy Business Plan has been developed. It contains both near-term and long-term business strategies that are relevant to future renewable power projects. Key elements of the Commerce Energy Business Plan were incorporated into the prioritization methodology. This makes the prioritization criteria both meaningful in ensuring cost-effective renewable energy

development from the local community's perspective and attractive to third party developers from a business perspective.

The full list of criteria for evaluation of identified projects has three major groups of criteria:

- Criteria from the Commerce Energy Business Plan
- Mini-Grid Benefits
- Technical (RD&D) Attributes

An objectives hierarchy model was developed to achieve a specific goal using different criteria and attributes and various alternatives. The criteria are scored individually for each potential renewable energy project. These decision criteria are the basis for a valid approach to ranking and selecting cost effective renewable resource projects for development within the mini-grid concept.

4.2 Project 1.1 Recommendations

The recommendations made here are aimed at the development of an approach for tailoring resource development within the mini-grid to meet its needs (electric generation and T&D reliability, and environmental).

An important element to this PIER program is the input resulting from Critical Program Reviews (CPR). The objective of the CPR process is for the Renewable Program Advisory Committee (RPAC), selected at the beginning of the program, to provide strategic guidance to the program. In addition, Project Advisory Committees (PAC) were selected for each individual projects so as to provide strategic guidance for each of the projects. The comments and recommendations provided by both the RPAC and the PACs are intended to provide advice from a wide group of industry experts yet not necessarily control the direction of the projects and the overall program. Recommendations made hear are intended to be responsive to those resulting from the CPR.

Program CPR Comments and Recommendations

On September 24, 2003, the Commerce Energy team met with the Program RPAC and Energy Commission Staff for a Critical Program Review meeting. At this meeting the results to date for Project 1.1 were presented. Subsequent to the meeting, Energy Commission Staff provided comments on the status of the Project 1.1. These comments are presented here.

A major focus of this program was to investigate the ability to use renewables in a distributed generation setting to help offset T&D costs while developing renewables indigenous to the

region. It isn't clear how this approach is being used in the project. For example, renewable projects are identified but seem to be treated as stand alone projects with the purpose of demonstrating a particular technology. It will be important to have the renewable demonstration projects coordinated to address the T&D issues.

One possible way in which this could be done would be to identify from the T&D analysis those areas within the mini-grid where T&D upgrades or expansions might be needed in the next decade. These areas could then be pinpointed via GIS and overlaid with available and technically appropriate renewable energy generators. In turn, anticipated costs of the upgrades or expansions would be identified to act as target costs for alternatives. Renewable resources in the proximate area of the anticipated upgrades or expansions would be identified and estimates of the potential renewable generating capacity for those spots quantified. By comparing the levelized costs of the renewable generating potential against the cost of upgrades or expansion would provide an economic feasibility for using renewables to offset or complement T&D upgrades or expansions. This approach provides Commerce Energy with a means to assess where to expand renewables in a manner that would benefit ratepayers, to identify the most appropriate mix of renewables, and assess its cost effectiveness relative to other options. However, the analyses conducted and presented to date do not indicate how Commerce Energy intends to relate the T&D situation in the mini-grid to the available renewable resources. An approach that links the T&D analysis to the renewables available in the area, and then identifies a clear pathway for implementing renewables should be identified as part of Commerce Energy's business plan approach.

Our (Energy Commission's) recommendation is that Commerce Energy develop and provide to the Energy Commission contract manager a clear business plan to the program that includes goals and objectives that will help make electricity more affordable and diverse to Commerce Energy's California electricity customers. The plan should include quantitative goals and objectives with associated timeframes by which Commerce Energy anticipates using technologies developed under the program. These goals and objectives should take into account the objectives already developed by Commerce Energy as follows:

- Develop and implement an approach for tailoring renewable resource development to the specific needs and available resources of local areas, or mini-grids
- Develop means of increasing landfill gas production, accelerating biodegradation and decreasing landfill generation lifecycle costs
- Improve the affordability of renewable energy produced from digester gas at sewage treatment plants
- Improve the economics of producing energy from animal waste
- Demonstrate the use of proper systems integration to enhance the performance of photovoltaic systems

- Demonstrate the use of a basic rating system to improve the flow of information on photovoltaic system performance
- Demonstrate the potential for taking advantage of cost economies by installing relatively large PV systems under common ownership arrangements

It will be important for Commerce Energy to integrate the various renewable energy technologies available within the mini-grid via the business plan approach. While renewable resources will be located in disparate parts of the mini-grid, the manner in which they are used to address current or future T&D problems will act as the basis for an integrated approach. Similarly, available renewable resources may prove unable to resolve current T&D problems. In that event, Commerce Energy should identify if renewable resources offer a prospect for addressing future problems, and identify what improvements in costs or performance are needed for renewables to play such a role.

Biogas and BI-PV Project Prioritization

One of the major objectives of the Planning and Analysis Project is the prioritization of candidate sites to participate in the Commerce Energy Energy's RD&D pilot program activities.

Recommended RD&D Projects

The prioritization results were such that natural dividing points between groups ("tiers") of projects were evident for both the biogas and BI-PV projects. For both sets, projects were divided into a Tier 1 (highest priority), a Tier 2 (secondary consideration as program schedule and resources allow) and a Tier 3 (removed from consideration under the Commerce Energy PIER program). Tier 1 projects are those that warrant further funding and implementation at this time. Tier 2 projects include those that may be implemented after requirements for Tier 1 projects are met. Tier 3 projects include those that do not sufficiently meet the combined goals of Commerce Energy business objectives and the PIER program to be implemented at this time. The Tier 1 recommended projects are listed here:

Biogas Projects—Tier 1

- San Bernardino County's Mid-Valley Landfill -- Unit 3 bioreactor project (Project 2.1)
- Gas production enhancement at City of Riverside's Riverside Water Quality Control Sewage Treatment Plant using ultrasound technology on waste-activated sludge (Project 2.2)
- Co-digestion of dairy manure with food processing waste at IEUA's RP-1 dairy manure digester facility for gas production enhancement (Project 3.1)

BI-PV Projects—Tier 1

- IEUA (formerly IKEA) Composting facility—a rooftop-installed array in Rancho Cucamonga
- San Bernardino County Maintenance Facility —an awning-installed array at the Chino Airport
- Civil Air Patrol Facility —a rooftop-installed array in Chino

Project Selection Criteria for Other Mini-Grids

Several factors played an important roll in ranking potential sites for future demonstration projects. These ranking criteria can help optimize the development of any fully realized mini-grid. Originally, the set of prioritization criteria included technical attributes of the projects, and benefits to the mini-grid that would accrue from the projects. Since the establishment of those original criteria, the Commerce Energy Business Plan has been developed, and it contains both financial and non-financial decision criteria that are relevant to these renewable power projects. Therefore, key elements of the Commerce Energy Business Plan were incorporated into this analysis. The full list of criteria for the evaluation of identified potential projects can be categorized into three major groups of criteria:

- Criteria from the Commerce Energy Business Plan
- Mini-Grid Benefits
- Technical (RD&D) Attributes

Those criteria that are most useful for other mini-grids are the mini-grid benefits and the technical attributes. The mini-grid benefits can be broken down further into non-financial and financial benefits. The non-financial mini-grid benefits include:

- New System Capacity (kW)
- Distribution System Deferral Benefit
- Distribution System Cost Savings Benefit
- Voltage Regulation Benefits
- Line Loss Reductions Benefits

The mini-grid financial benefits include:

- Quantifiable Benefit / Total Cost Ratio
- NPV of Net Benefits to Mini-Grid
- Total Deferred Utility Capital Cost

The technical attributes include:

- Permitting Capability
- Technology Risk

- Lead Time
- Host / Developer Economics and Financing

These prioritization factors are a necessary component in the process of developing a fully realized mini-grid.

T&D Mini-grid Recommended Studies

It is necessary to conduct a power flow analysis study to determine where within a mini-grid the optimal benefits can be achieved and determine the magnitude of those benefits. The timing when certain distribution circuits and transformers become overloaded will also assist in the prioritization of renewable resource development and optimize the benefits.

Further detailed studies in the following areas are recommended to supplement the power flow study results from Project 1.1 and ensure successful operation of the mini-grid (and other distribution systems) with significant penetration of distributed generation on the feeders:

- A detailed interconnection study which considers relaying requirements, integrated control of distribution system voltage, reactive power scheduling, communication requirements and short circuit duty impacts with high penetration levels of the distributed biogas and BI-PV generation installed.
- A dynamic study of the transient response of high penetration levels of distributed biogas and BI-PV generation to disturbances on nearby feeders or substations to test the stability of the DG during appropriate transient events.

The scope of the work associated with these two recommended studies is presented here.

Study Pertinent Interconnection Requirements

Several pertinent interconnection practices and standards documents will be reviewed as part of this task. Rule 21 interconnection requirements for SCE, PG&E and SDG&E will be reviewed. Interconnection requirements developed in IEEE P1547 and Texas will also be reviewed for comparison purposes. Interconnection requirements are expected to vary as a function of generation type, generation size, location and cumulative penetration level on the distribution system feeders. Appropriate PV and biogas generation characteristics will be identified for potential renewable additions.

Three potential high-penetration renewable scenarios will be developed for selected feeders. These scenarios are expected to be compatible with the DG feeder penetration scenarios in the power flow modeling task (Task 1.1.9) in Project 1.1, where possible.

The interconnection study will consider relaying requirements, integrated control of distribution system voltage, reactive power scheduling, communication requirements, and short circuit duty impacts for the three high-penetration biogas and BI-PV penetration scenarios. Other pertinent interconnection requirements and issues identified during the course of this task will also be summarized where appropriate.

Dynamic study of three BI-PV and biogas high-penetration scenarios

Appropriate PV and biogas generator models and exciter models will be developed for the three potential BI-PV and biogas scenarios. The local distribution feeders, loads and distribution substation facilities will be modeled and connected to the transmission system, which will be represented as an infinite bus.

A dynamic study of the transient response of the three high-penetration scenarios of distributed biogas and BI-PV generation to disturbances on nearby feeders and substations will then be performed to determine the stability of the DG. A series of 3-phase faults will be examined at up to five selected locations near the feeders containing the DG in order to examine the system performance with the DG in operation. Dynamic runs will be performed during peak load and light load conditions used in the steady-state power flow studies conducted in Project 1.1. Transient stability will be tested with dynamic runs made for ten seconds. Both voltage and swing angle at the DG locations will be plotted for each of the disturbances.

Revisions on M&E

In the original Commerce Energy Energy program proposal, the development of M&E plans for the individual projects under the program were specified. However, an M&E plan for the entire Commerce Energy Energy program was not. Given that the success of the overall program has some degree of independence from the success of the individual projects within the program, it was recommended that an overall M&E plan be developed. Subsequently, an M&E plan for the entire program has been added. This addition is in keeping with the intent of the M&E process to examine and assess the success of all program elements, including those at the overall program level.

There may be other revisions to the M&E plans for individual projects as they progress due to modification to the projects resulting from recommendations made during scheduled critical project review meetings and other recommendations from the team and the Energy Commission.

4.3 Benefits to California

The PIER Commerce Energy Energy Biogas/PV Mini-Grid Renewable Resources Program will yield numerous benefits to the State of California. Some of the benefits will be easily quantifiable while others will be softer and not easily quantified. The non-quantifiable benefits include:

- Mini-Grid Concept Development
- Employment
- Economic growth
- Fuel Diversity
- ESP and Participant Benefits
- Meeting the State's Renewable Portfolio Standard
- Identification of high-value PV and biogas applications

The quantifiable benefits include:

- T&D system deferral of capital expenditures
- T&D system reliability improvements
- Landfill capital and operating cost reductions
- Environmental improvements

Non-Quantifiable Benefits to California

Mini-Grid Concept Development

The mini-grid concept seeks to tailor resource development to the specific needs and resources of localized areas of the electric distribution system. The specific renewable resources selected (landfill gas, biogas from livestock and food processing waste, and biogas from wastewater treatment facilities) are particularly well suited to this goal. Unlike geothermal or wind resources, these selected resources tend to be located close to populated areas, relatively close to electric transmission and distribution facilities, and may be found in concentrated pockets near electric system load centers.

Employment

Long term employment stands to benefit from the development of mini-grids. DG system designers, installers, operation and maintenance professionals will be required should the concept be realized.

Economic growth

California's long term economic growth will benefit by the application of the mini-grid concept. There are economic benefits that will go to the State as a whole but more importantly the local communities where the mini-grids are developed will benefit as well.

Fuel Diversity

No individual fuel is capable of providing the energy to meet all electricity requirements. A diverse fuel mix protects electricity producers and consumers from situations such as fuel unavailability, fuel price fluctuations, and changes in regulatory practices. The mini-grid concept promotes fuel diversity.

ESP and Participant Benefits

Energy service providers and participating customers can benefit by the business relationships that can be arranged as a result of the development of mini-grids. New business models are likely to results where greater benefits are realized by parties acting together rather than on their own. No one market actor can realize all the possible benefits without developing a business relationship with other parties. For example, tax benefits may be available to an ESP and not to the customer whereas the property ownership obstacles may exist for the ESP and not the customer. The two parties together can benefit by developing a new business relationship and developing available renewable resources.

Meeting the State's Renewable Portfolio Standard (RPS)

By promoting the mini-grid concept, the State will benefit from a regulatory perspective in that it will be further promoting the development of renewable resources and contributing to its RPS goals.

Identification of high-value PV and biogas applications

The mini-grid concept understudy provides a mechanism or process for the identification and prioritization of high-value PV and biogas applications. The benefits assessment and project prioritization processes developed here ensure that the projects with the greatest value are identified.

Quantifiable Benefits to California

T&D system deferral of capital expenditures

By assessing the local T&D system in which mini-grids are developed, the deferral of system upgrades can potentially be deferred by deliberate development of well positioned renewable electric generation. T&D system upgrades can be very expensive and by deferring them for a

number of years, the local T&D provider will not incur these capital costs and will not need to pass them on to its customers.

T&D system reliability improvements

Other electric distribution system benefits are incurred by the development of significant quantities of localized distributed generation. There are voltage and VAR support benefits to be had which reduce the probability of outages for customers connected to the distribution system.

Landfill capital and operating cost reductions

The bioreactor concept under study in the Commerce Energy Program has the potential for significant cost reduction benefits. The bioreactor has the potential to increase the amount of waste that can be placed in a landfill per acre as well as reduce the time and expense associated with the long term monitoring and maintenance of the landfill after it has closed and cannot accept anymore waste.

Environmental improvements

Air pollution and ground water contamination are two potential environmental hazards that exist in areas with high concentrations of biogas resources. By aggressively developing biogas to energy projects in these localized areas, environmental improvements can be accrued.

4.4 Summary of Conclusions and Recommendations

The Program Planning and Analysis Project developed an approach for tailoring resource development within a mini-grid to help meet the local needs for electric generation, T&D reliability and environmental preservation. The approach consists of the following five elements:

- Identification of candidate study area
- Inventory of renewable resources
- Assess market potential
- Assess T&D grid impacts of fully realized mini-grid
- Prioritization of renewable DG projects within mini-grid

This approach can be replicated in other locations throughout California. The area studied in this project has an abundance of biogas (LF, WWT, Dairy waste and food waste) and PV resources. It was found that the combination of biogas and non-residential BI-PV electric generation produces an excellent match to the local electric demand profile.

It is expected that the mini-grid concept will become more viable as green tag and GHG credit markets evolve. Other financial market barriers can be addressed through continued public funding and legislative action. New ownership models similar to the one being tested by Commerce Energy Energy and IEUA can also remove market barriers.

Further research, such as that being performed under the Commerce Energy Energy Program, can improve the cost effectiveness of renewable distributed generation suitable for use in a mini-grid. However, there is a need for further research on DG impacts to the local T&D system to ensure that system reliability is not jeopardized.

For a mini-grid to be fully realized, an unprecedented level of cooperation between the local T&D owner, the State and local government agencies is required. These market actors must work together during all phases of the process to ensure that all the benefits of the mini-grid are achieved. This programmatic approach requires a champion and the Energy Commission is the logical choice to fill this roll.

Endnotes

The following endnotes/footnotes are contained within this Report.
(Sections referenced indicated where they appear within the report):

- **Section 3:** "Over $100 million dollars of ratepayer funded incentives are currently available for BI-PV systems statewide. Continued availability of such financial support depends on political, regulatory and other circumstances and therefore is uncertain."

Glossary

The following Acronyms are contained within this Report:

- **AD**: Anaerobic Digester/Digestion
- **AU**: Animal Unit
- **BI-PV**: Building-Integrated Photovoltaic
- **BOD**: Biochemical Oxygen Demand
- **CAD**: Centralized Anaerobic Digester
- **COMMISSION**: California Energy Commission
- **CPR**: Critical Program/Project Review
- **DOE**: U.S. Department of Energy
- **EUIs**: Energy Use Intensities
- **GHG**: Greenhouse Gas
- **GIS**: Geographical Information System
- **IEUA**: Inland Empire Utility Agency
- **IRR**: Internal Rates of Return
- **LFG**: Landfill Gas
- **M&E**: Measurement & Evaluation
- **NREL**: National Renewable Energy Lab
- **PG&E**: Pacific Gas & Electric
- **PIER**: Public Interest Energy Research
- **PV**: Photovoltaic
- **RD&D**: Research, Development and Demonstration
- **RECs**: Renewable Energy Credits
- **REDI**: Renewable Energy Development Institute
- **RPAC**: Renewable Program Advisory Committee
- **SARWQCB**: Santa Ana Regional Water Quality Control Board
- **SCE**: Southern California Edison
- **SDG&E**: San Diego Gas & Electric
- **STP**: Sewage Treatment Plants
- **T&D**: Transmission & Distribution
- **TAC**: Technical Advisory Committee
- **TPY**: Tons Per Year
- **WWT**: Wastewater Treatment
- **ZECO**: Zaininger Engineering Company

References

The following documents have been referenced within this Report
(Sections referenced indicated where they are contained within this Report):

- **Section 2**: Regional Economic Research, Inc. – "*Estimation of Hurdle Rates Applicable to Energy Related Investments*", June 25, 1989.
- **Section 3**: California Energy Commission – "*2002 – 2012 Electricity Outlook Report*" - (Page 21), February 2002
- **Section 3**: Itron, Inc. – "*Project Prioritization Assessment Task 1.1.10 Final Report*", April 2004.